ESTIMATING AND COSTING PRE-CAST CONCRETE PRODUCTS AND CAST STONE

BY

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PREFACE

IN attempting the compilation of a book on estimating and costing of pre-cast stone and cast concrete products, the author does so realising that no other book has previously been published which specifically deals with this subject.

Many of the methods described for arriving at basic figures, i.e. prices per cubic foot or per unit, have been devised by the author and used for a number of years. The object is to estimate the true cost as closely as possible. It is easy to quote prices when, either through demand or lack of competition, they can be kept high, but the purpose of this book is to explain methods of estimating closely.

Because rates of pay vary throughout the country and alter from time to time, the measure of labour adopted is a unit cost which is described as " minutes per cubic foot," so that a reliable set of labour costs once recorded never becomes obsolete unless manufacturing processes are altered. No basis of a price per cubic foot could of course be given in this book for any particular product that could be safely relied on by all manufacturers, because methods vary so much in nearly all factories and some employ mechanical devices to a greater extent than others. The question of maintaining good production and satisfactory costs is best solved by bonus or piece-work schemes. The author knows cases where piece-work has increased production by some 60 per cent. It is for this reason that all items of labour are analysed as far as possible so that a manufacturer can cost the various processes and co-ordinate them into a complete estimating record.

The book is chiefly concerned with the estimating and costing of products made by general products manufacturers, because it is the costing of different sizes, shapes, quantities, qualities, and finishes of products that makes so much complication. On the other hand, those who specialise in the manufacture of standardised products probably know their costs to very fine limits, as their systems can be comparatively simple.

Clocking and time-sheet systems are seldom satisfactory in a products factory, due chiefly to the excessive amount of clerical work required to co-ordinate the information and because the type of semi-skilled man employed cannot be relied upon to give accurate statistical information.

An estimate at the best is only an approximate calculation of expense, and, without some knowledge of costs, close estimating can never be undertaken without grave risk of error. The importance of accurate

estimating cannot be over-emphasised—it is the only means of building a bigger business or maintaining a profitable business, for without a knowledge of what really is a close estimate the price may be either too high, which even the best salesman cannot cope with every time, or so low as to result in a loss. The manufacturer is often tempted by offers below his quotation, but how many know just how much lower the price can be without becoming dangerous? It is hoped, therefore, that this book will be useful to estimators in the pre-cast concrete industry.

F. H. F.

LONDON, 1943.

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INTRODUCTION

Before a tender can be given, two auxiliary estimates have to be prepared, namely, an estimate of quantities and an estimate of unit costs.

An estimate of quantities should describe as closely as possible all the items, the length or number of each, with sizes that enable the volume of material to be calculated, and a drawing should also be provided if there is any likelihood of a written description not being clearly interpreted. Labours should also be enumerated.

An estimate of unit cost enables the various items of quantities to be priced as accurately as the skill of the estimator will allow. Unit cost includes

(1) Cost of materials for concrete;
(2) Labour charges in casting;
(3) Indirect labour charges;
(4) Mould charges of material and labour;
(5) Steel charges of material and labour;
(6) Haulage charges;
(7) Overhead charges and profit; and
(8) Sundries.

Most of these items so far as general concrete products are concerned are based on a cubic foot measure. Items of steel reinforcement, however, are often more conveniently added as a price per linear foot or a price per unit after the other items have been computed and totalled to a basic figure. Often the steel is kept separate and totalled to a weight and priced at per ton or cwt.

Sometimes the basic figure is computed as an average price per cubic foot for a complete set of quantities. The only thing to recommend this method is the speed with which a bill of quantities can be priced, but it is liable to lead to inaccuracies and the extra time required to make a correct estimate of cost is usually well worth while. Indeed, an incorrect estimate may easily lead to financial loss.

Actually the methods which will be shown in detail later will be co-ordinated so that by their use accurate estimates can always be given quickly. The figures and examples are illustrative of method only and should be verified by manufacturers who wish to adopt similar methods.

Often the tenders of competent firms vary even in districts where the raw materials and labour costs are the same. This divergency can easily be the result of different on-costs and profits, but more often than not it is the result of being unable correctly to assess the effect of varying volume on labour charges. The unit labour costs of an article of, say, ½ cub. ft. and 3 cub. ft. can vary by many hundreds per cent., and it is this effect on prices which causes so much complication in estimating.

CHAPTER I

ENQUIRIES

PRACTICALLY all enquiries that are received by manufacturers are "live." As a rule the architect discusses the question of materials with his client, and with his knowledge of approximate prices he can advise his client on the desirability or otherwise of using pre-cast concrete or cast stone. Then is the time when exact detailed quantities are prepared, so that by the time they are sent to products manufacturers it is certain that the particular enquiry can be looked upon as a potential order, provided, of course, that the price is right at the outset. This is important for many reasons. First, a second opportunity to tender is seldom given, and a buyer will favour the firm which has the ability to put the right price in at the correct time. When this happens it is a certainty that the manufacturer will always remain on the particular buyer's enquiry list, and so have an opportunity to quote for future work. Some firms quote high prices in the hope that their salesmen may be able to make a lower offer if this should be necessary or possible. This practice may be profitable on a few occasions, but it then becomes the habit of the customer to expect reductions on all estimates to the point where the manufacturer does not know when he is being bluffed.

Enquiries may be received either in the form of carefully described and dimensioned quantities, or by a drawing from which the manufacturer has to extract his own particulars. If there is anything the least unusual about any particular casting it is always preferable to ask for a drawing from which to estimate, although quantities are good enough for everyday products.

CHAPTER II

QUANTITIES

BILLS of quantities list the various items in units of length, superficial area, volume, and number, such as linear yards, linear feet, super yards, super feet, cubic yards, cubic feet, or number off. The unit of measure may head a column which is then devoted entirely to all items in the same unit of measurement, as illustrated in *Fig.* 1.

Yd.	Ft.	No.				£	s.	d.
1½			cube	Concrete base under kerb composed of 4 parts ¾″ clean shingle, 2 parts sand, 1 part Portland cement.				
350			super	18″×9″×9″ hollow concrete revetment blocks with 2″ thick walls and central web.				
47			lin.	5″×10″ half-battered precast granite concrete kerb.				
	950		cube	Cast stone plain ashlar, average 6¾″ bed.				
	78		super	Drafted margins to ashlar, 8 bats per inch.				
	120		lin.	12″×3″ once-weathered and twice-throated coping.				
		2	No.	Fair ends.				

Fig. 1.

The items can also be written below each other, each unit of measurement being written immediately after the quantity as illustrated in *Fig.* 2.

No.				£	s.	d.
1½	cub. yd.	Concrete base under kerb composed of 4 parts ¾″ clean shingle, 2 parts sand, 1 part Portland cement.				
350	super. yd.	18″×9″×9″ hollow concrete revetment blocks with 2″ thick walls, and central web.				
47	lin. yd.	5″×10″ half-battered precast granite concrete kerb.				
950	cub. ft.	Cast stone plain ashlar, average 6¾″ bed.				
78	sup. ft.	Drafted margins to ashlar, 8 bats per inch.				
120	lin. ft.	12″×3″ once-weathered and twice-throated coping.				
2	No.	Fair ends.				

Fig. 2.

Fixing.

The quantities are often an exact copy of the original bill, and sometimes include references to hoisting, bedding and fixing, etc. In the case of concrete products the contractor usually intends to fix, so that to avoid confusion it is as well always to delete such references. In the case of cast stone, architects often prefer the manufacturer to fix his own material, as his trained men take a great deal more care and interest in the execution of the work. Sometimes small jobs are uneconomic for the manufacturer to fix, but every tender should explicitly state whether fixing is included or not.

Quantities from Drawings.

When a drawing is sent to the manufacturer for the preparation of his own quantities, it is necessary that they be prepared with as much skill as possible, for which reason a system of taking off should be evolved. It matters little how they are taken off so long as the result is correct, but system and method, as well as tidiness, help a great deal to avoid omissions. One method is to start from the bottom of the drawing and work up, billing everything as it is seen, and to separate the items later according to their kind. The more usual way, however, is to start at the bottom of the building, and bill everything of a kind as it is found in the process of working up, taking care to mark on the drawing the items that have been billed. Thus in a cast-stone faced building the plinth would first be measured, followed by ashlar over the entire facing where it occurs, then perhaps door architraves, sills, transoms, mullions, heads, band courses, cornices, copings, etc.

The quantities to be taken off are usually separately described in a specification, which states the nature and quality of materials. It is of the utmost importance to describe very carefully the nature of the material that the manufacturer intends to supply if the specification does not make this clear, because one firm may quote for a material manufactured with grey Portland cement whereas another may include a white finished product which is much more expensive and may result in the loss of the order.

On many occasions only $\frac{1}{8}$th-scale (1 in. = 8 ft.) drawings are supplied from which the manufacturer is expected to measure quantities. Unless actual sections of units are specified it is practically impossible for two persons to arrive at the same result, and of course no tender can be relied on. There have been cases where architects have placed an order with the lowest tenderer, whose measured volume of cube has also been the lowest, but at the end of the contract the price has exceeded the highest bid on account of extras, due to lack of information on the original

⅛th-scale drawings. It is always a good plan to state in such cases: "The quantities have been prepared from ⅛th-scale drawings with as much accuracy as possible, but, if any variations subsequently occur to increase the cubic volume of any item, extras will be charged."

Standard Method of Measurement.

There is a Standard Method of Measurement of Building Works, published by The Chartered Surveyors' Institution and The National Federation of Building Trades Employers, with the object of securing greater accuracy and uniformity of description in the preparation of quantities. By permission these are here reproduced, altered in one or two instances to comply with cast-stone requirements.

ARTIFICIAL STONE.

"59.—Artificial stone, terra cotta, and similar work shall be measured and given as described for natural stone; work so given shall include all moulds and also for filling of voids with concrete the composition of which shall be stated."

STONE MASON.

"23.—Generally.—

"(*a*) Stonework in elevations differing in character shall be given under separate headings. Stonework in dressings shall be given separately under the heading of stonework in dressings.

"(*b*) The stone, mortar, and labour shall be described, and it shall be stated if the stone is to be set on its natural bed or otherwise.

"(*c*) Stone shall be measured the smallest rectangular cube from which each stone can be obtained, to which shall be added the thickness of the mortar bed and joint; fractions of an inch if half an inch or over shall be measured as the full inch, those less than half an inch shall be neglected. Where arch stones are required to be set with the quarry bed horizontal they shall be measured as out of blocks sufficiently large to obtain this result.

"(*d*) Stone in tracery shall be given in feet superficial as hereinafter described and each stone shall be measured the smallest rectangle from which it can be obtained.

"(*e*) Stones 6 ft. long and over shall be given separately and the length stated.

"(*f*) Stones of 40 ft. cubic content shall be given separately and described in ranges of 10 ft.

"24.—Cube Stonework.—

"(*a*) The stonework generally shall be given in feet cube including the finish to face which shall be described and including all labours (except as hereinafter stated), necessary arris joggles, templets, etc., and hoisting not exceeding 40 ft. above ground, and setting, jointing, and pointing, and for protecting with slurry and cleaning off and rubbing down on completion if required. An item of extra hoisting shall be given for all stone 40 ft. or more above the ground in stages of 20 ft.

"(*b*) The labour on the stone shall be described as plain, sunk, moulded, circular, circular sunk, circular circular, circular circular sunk, etc.; if any of the labours be stopped or returned it shall be so stated.

" (c) The stone with the labours above described shall be given in feet cube under the following or similar classifications:

(1) Pilasters and quoins.
(2) Pilasters sunk to entasis.
(3) Caps and bases to pilasters (stating the number).
(4) Jambs.
(5) Lintels.
(6) Springers.
(7) Voussoirs.
(8) Keystones.
(9) Columns (stating the diameter).
(10) Columns sunk to entasis (ditto).
(11) Caps and bases to columns (stating the number).
(12) Large cornices and string courses (stating the section).
(13) Angle stones to last (stating the number).

" 25.—Stonework to be given superficial.—

" The following shall be given in feet superficial stating the thickness and describing the face work and other labours : Plain ashlar, rusticated ashlar describing the rustication, tracery, and all stones 4 in. on bed or under.

" 26.—Stonework to be given Run.—

" (a) The following shall be given in feet run stating the sizes : Small cornices and string courses ; plinth courses ; sills ; copings and similar small horizontal members ; mullions and transoms.

" (b) Angle stones, kneelers, etc., to the above shall be enumerated stating the size and given immediately following the item. Alternatively they shall be given in feet cube stating the number.

" (c) Stoolings and similar items shall be enumerated and described.

" 27.—Stonework to be Enumerated.—

" The following and similar items shall be enumerated and described stating the sizes : Balusters ; finials ; crockets ; terminals and small caps and bases to pilasters.

" 28.—Stonework in Circular Walls or Walls built Battering.—

" Stonework in walls circular on plan or built battering shall be given separately and so described and the radius or batter stated.

" 29.—Labours to be given Separately.—

" (a) Where the stonework is given in feet cube or in feet superficial the following labours shall be measured separately and given in feet run : Grooves, fluting to columns, and similar items.

" (b) If stopped these labours shall be so described and the stops enumerated.

" (c) Where the stone is given in feet run these labours shall be described with the item.

" 30.—Labour in Checking or Sinking Stone for Steelwork.—

" (a) Where stone is checked or sunk at back to fit steelwork this labour shall be given in feet run, stating the nature of the sinking and giving the average width of same in stages of 6 in. and the average depth in stages of 3 in. Where stone is notched and checked to fit between flanges of rolled steel joists or stanchions, this labour shall be given in feet run and the size of the joist or stanchion stated.

" (b) Sinkings for gusset plates, brackets, ends of joists, and the like shall be enumerated and described.

" 31.—Labour to Ornaments, Dentils, etc.—

" (*a*) Running ornaments such as bead and reel, egg and dart, dentil courses, and similar items shall, if worked by the mason (as distinct from moulding), be measured separately and given in feet run ; a full description of the item shall be given, stating the spacing.

" (*b*) Angle enrichments to the above shall be enumerated and described.

" 32.—Labours to be Enumerated.—

" The following and similar labours shall be enumerated : Mortices (except those required for fixing stonework) ; leading to bars ; secret arch joints ; perforations for pipes, stating whether through ornamental or plain work ; sunk panels if under 1 ft. superficial ; and half balusters worked on dies.

" 33.—Cramps, etc.—

" Metal cramps, slate and metal dowels, lead plugs, and similar items shall be enumerated and described and shall include for mortices.

" 34.—Carving or Sculpture.—

" (*a*) Detailed sketches or descriptions of carving and sculpture shall be given.

" (*b*) Failing such sketches or descriptions, or in the event of a special carver or sculptor being required, the items shall be enumerated at prime cost prices which shall include the cost of models ; alternatively a provisional sum shall be given.

" (*c*) If large-size blocks are required, or a special quality of stone is to be selected for carving or sculpture, it shall be so stated.

" (*d*) Boasting for carving shall be described.

" (*e*) If the mason is to work mouldings, etc., up to carving, the items shall be enumerated.

" (*f*) If accommodation on site or in mason's yard, or if special scaffolding, screens, or shelters are required for carver or sculptor, the description of same shall be given and provision made for attendance and cleaning up after the craftsman.

PRE-CAST CONCRETE WORK.

" 30.—Generally.—

" (*a*) Pre-cast work shall be given separately and measured the smallest rectangular cube from which it could be obtained if it were natural stone ; fractions of an inch if half an inch or over shall be measured as a whole inch, those less than half an inch shall be neglected.

" (*b*) The labour on each item shall be described.

" (*c*) Pre-cast work shall be described as including all moulds, finished faces, and hoisting and setting ; the reinforcement shall be described and included with each item.

" (*d*) Cornices, string-courses, plinths, sills, copings, lintels, and other similar items shall be given in feet run and the sizes stated ; those over 7 ft. and not exceeding 10 ft. in length and those above 10 ft. in length shall be given separately, and the average length and number in each of these groups shall be stated. Angle stones, kneelers, bonders, stoolings, and similar items shall be enumerated.

" 31.—Steps and Landings.—

" (*a*) Steps (other than spandril steps and winders) shall be given in feet run and described ; ends of steps shall be enumerated and described. Spandril steps, winders, and landings shall be enumerated and the extreme sizes stated.

" (*b*) Notchings and holes for pipes and the like shall be enumerated and described."

Although, as stated, pre-cast concrete work is " measured the smallest rectangular cube from which it could be obtained if it were natural stone," it is not always wise to apply this to repetition units where the net volume may be considerably less than the overall volume. It is a good thing to state the overall dimensions, as this limits the size, and to state also the net cube of concrete contained by the block. The more accurate computation reduces the cost of material and haulage. It would not be right to say it also reduces labour costs, because obviously whichever way the stone is measured it will make no difference to what it costs to make. Here it should be pointed out that, if labour costs are based on overall measurements, then estimates should be prepared similarly, but it is good practice when dealing with very large or mass-production units to keep the costs and estimates on a net cube basis.

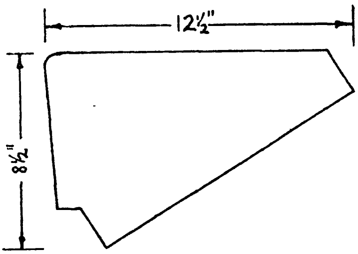


Fig. 3.

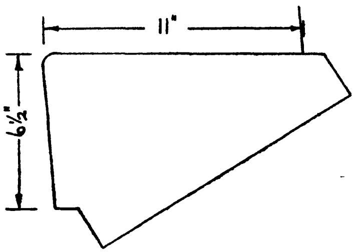


Fig. 4.

As an example, if a spandrel step 4 ft. long is cubed as shown in *Fig*. 3, $\frac{12\frac{1}{2} \text{ in.} \times 8\frac{1}{2} \text{ in.}}{144} \times 4 \text{ ft.} = 2{\cdot}95$ cub. ft., and this figure is used in arriving at the labour cost per cubic foot, it would be wrong to use this cost in estimating for a spandrel step where the cube was based on a tread and rise measurement (see *Fig*. 4)

$$\frac{11 \text{ in.} \times 6\frac{1}{2} \text{ in.}}{144} \times 4{\cdot}0 = 2{\cdot}0 \text{ cub. ft.,}$$

because if the actual cost of making the step was 2*s*. 3*d*. by one method the cost per cubic foot would be $\frac{2s.\ 3d.}{2{\cdot}95} = 9{\cdot}2$ pence per cubic foot, and by another method $\frac{2s.\ 3d.}{2{\cdot}0} = 1s.\ 1\frac{1}{2}d.$ per cubic foot. Hence the estimator must know the basis on which the costs are calculated, as described in the following chapter.

CHAPTER III

CALCULATION OF AREAS AND VOLUMES

THE branch of mathematics mostly used in estimating is mensuration, which deals with areas and volumes. Surface areas must be known for estimating the cost of moulds, and surface finishes such as rubbing, tooling, and polishing. Volumes are calculated to arrive at costs of materials, labour, and weights for transport purposes.

Units of Measurement.

SURFACES, CROSS SECTIONS, AND STRENGTHS.—The general terms in use as units of measurement of surface areas or cross sections are:

Square inch, generally only used in reference to cross sections, metals, and strengths of materials.

Square foot, the usual unit of measurement for surface area of concrete products; also used for cross sections.

Square yard, used over large surface areas such as paving.

144 square inches = 1 square foot.
9 square feet = 1 square yard.

VOLUMES.—In volumetric calculations the units of measurement are:

Cubic inch, usually adopted to cube one linear foot of cross section, for reducing to cubic feet.

Cubic foot, the usual unit of measurement in calculations of estimates. The cost of materials, casting-labour, mould-labour, and materials, haulage, etc., is usually quoted as a basic price per cubic foot. Practically all calculations for arriving at itemised prices in a bill of quantities are computed by the product of the volume in cubic feet and the basic cost per cubic foot.

Cubic yard, the unit of measurement for mass concrete and sand and ballast.

1728 cubic inches = 1 cubic foot.
27 cubic feet = 1 cubic yard.

Trigonometrical Ratios of Angles.

In any right-angled triangle certain constant ratios exist between the sides for a given angle. Thus, knowing two sides, the angles of the triangle can be calculated; or, given an angle and one side, the other sides can be calculated.

The angle under consideration is often designated θ (Theta). The

perpendicular (p) is always opposite this angle and the base (b) is adjacent, making an arm of the right angle. The hypotenuse is opposite the right angle (*Fig.* 5).

$$\text{Sin } \theta = \frac{\text{perpendicular}}{\text{hypotenuse}} = \frac{p}{h}.$$

$$\text{Cos } \theta = \frac{\text{base}}{\text{hypotenuse}} = \frac{b}{h}.$$

$$\text{Tan } \theta = \frac{\text{perpendicular}}{\text{base}} = \frac{p}{b}.$$

The values of these ratios can be found in most mathematical tables. In a right-angled triangle $b^2 + p^2 = h^2$.

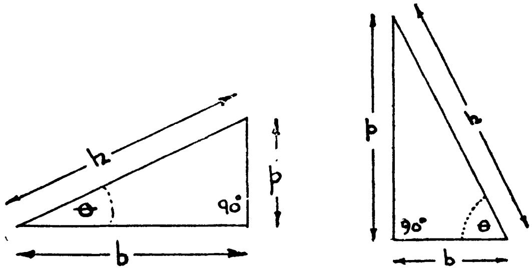


Fig. 5.

Formulæ for Surface Areas.

	Formulæ.
Square (*Fig.* 6).—The product of two sides or the base multiplied by the height . . .	$a \times b$
Rectangle (*Fig.* 7).—The base multiplied by the perpendicular height.	$a \times b$
Rhomboid or Parallelogram (*Fig.* 8).—Multiply the base by the perpendicular height . .	$a \times h$

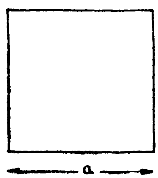


Fig. 6.

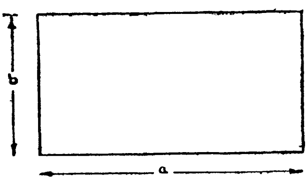


Fig. 7.

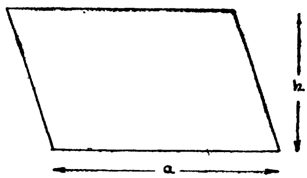


Fig. 8.

Triangle (*Fig.* 9).—Multiply the base by the perpendicular height and divide by two . . $\dfrac{a \times h}{2}$

Trapezoid (*Fig.* 10).—Multiply one-half the sum of the two parallel sides by the perpendicular distance between them . . . . . . $\dfrac{a+b}{2} \times h$

Regular Polygons (*Fig.* 11).—Add together the areas of the equal triangles. If the side a and the height h are known and the number of sides is n, then the area is . . . . $n\left(\dfrac{a \times h}{2}\right)$

If only the base a is given, proceed as follows to find the height h. Divide 360 deg. by the number of sides $\dfrac{360}{n}$ = angle θ. By referring to a table of natural tangents, the tangent of half the angle $\theta = \dfrac{a}{2h}$. $h = \dfrac{a}{2 \tan \frac{1}{2}\theta}$ and area = . . . $n\left(\dfrac{a^2}{4 \tan \frac{1}{2}\theta}\right)$

If the length of side a is given (*Fig.* 11), then the area of a regular polygon (including a triangle and a square) is

No. of sides	Area
3	$0{\cdot}433a^2$
4	$1{\cdot}000a^2$
5	$1{\cdot}7205a^2$
6	$2{\cdot}5981a^2$
7	$3{\cdot}6339a^2$
8	$4{\cdot}8284a^2$
9	$6{\cdot}1818a^2$
10	$7{\cdot}6946a^2$

Circle (*Fig.* 12).—Multiply the radius squared by 3·1416 (π) . . . . πr^2

Or multiply the diameter squared by 3·1416 and divide by 4 . . . . $\dfrac{\pi d^2}{4}$

Or multiply the diameter squared by 0·7854 $0{\cdot}7854d^2$

Ellipse (*Fig.* 13).—Multiply the product of the two axes by $\dfrac{\pi}{4}$ . . . . $\dfrac{\pi}{4}xy$

Sector of Circle (*Fig.* 14).—The angle θ must be known or calculated, then the area = $\dfrac{\theta}{360 \text{ deg.}}$ multiplied by area of circle . . . . . $\dfrac{\theta}{360 \text{ deg.}} \times \pi r^2$

Segment of Circle (*Fig.* 15).—The angle θ must be known or calculated. Then the area = the area of the sector minus the area of the triangle xyz . $\left(\dfrac{\theta}{360 \text{ deg.}} \times \pi r^2\right) - \dfrac{ar \cos \frac{1}{2}\theta}{2}$

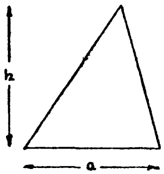


Fig. 9.

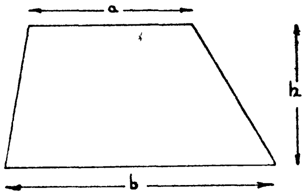


Fig. 10.

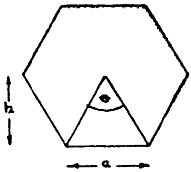


Fig. 11.

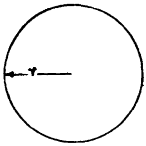


Fig. 12.

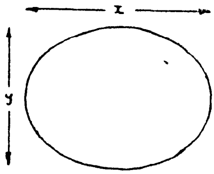


Fig. 13.

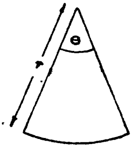


Fig. 14.

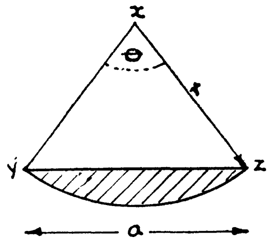


Fig. 15.

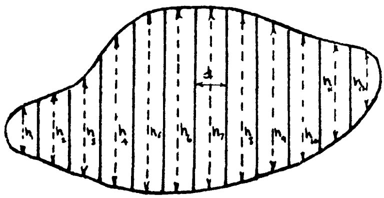


Fig. 16.

Irregular Area (*Fig.* 16).—It is necessary to draw the figure to scale and divide it into a number of equal parts of width d. The greater the number of parts the greater the accuracy. Measure the mid ordinate h of each part (n) and take their sum and multiply by d. This is the area . . . $d(h_1 + h_2, \text{etc.})$

A very convenient method of determining the area of an irregular figure is to draw it accurately on graph paper, calculating very carefully the area represented by one square, then count the number of whole squares and those more than half a square, neglecting those less than half a square. This total multiplied by the area of one square (not forgetting if it is drawn to scale) gives a very close approximation of the area, and is near enough for most practical purposes.

Other useful information often required in making calculations of area are the formulæ relating to sectors and segments of a circle (*Fig.* 17).

V = versed sine ; C = half chord ; R = radius ; O = any ordinate ; X = distance of ordinate from centre of BD.

$$O = \sqrt{R^2 - X^2} - (R - V)$$

$$R = \frac{V^2 + C^2}{2V}$$

$$V = R - \sqrt{R^2 - C^2}$$

$$X = \sqrt{R^2 - (O + R - V)^2}$$

Area of a segment $= \frac{4V}{3}\sqrt{(0{\cdot}625V)^2 + C^2}$

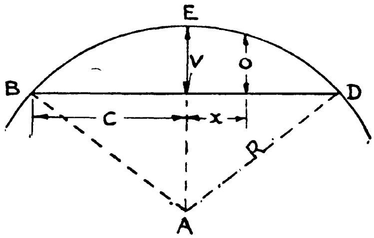


Fig. 17.

Formulæ for Cubing.

	Formulæ
Right Prism (*Fig.* 18).—A right prism is any solid which has its axis at right angles to its base and has the same section throughout. The base can have any number of sides, which may be of different length. The volume is the area of the base multiplied by the height	Area of base $\times h$
Cylinder (*Fig.* 19).—A special case of a right prism generally having a circular or elliptical base. Its volume is, as before, the area of the base multiplied by the height	$\pi r^2 \times h$
Pyramid (*Fig.* 20).—A solid having a base and three or more triangular faces. Its volume is the area of the base multiplied by one-third of the perpendicular height	Area of base $\times \frac{h}{3}$
Cone (*Fig.* 21).—A cone is a special case of a pyramid in which the base is a circle. Its volume is the area of the base multiplied by one-third of its perpendicular height	$\pi r^2 \times \frac{h}{3}$

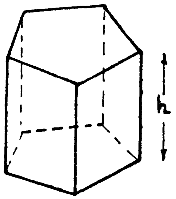


Fig. 18.

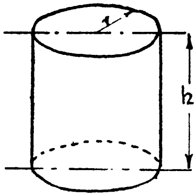


Fig. 19.

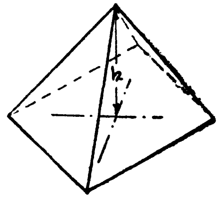


Fig. 20.

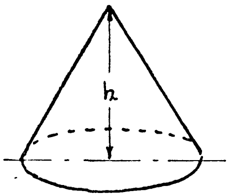


Fig. 21.

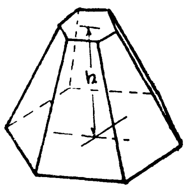


Fig. 22.

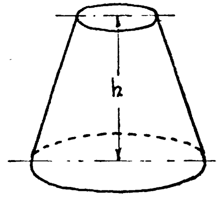


Fig. 23.

Frusta of Cone and Pyramid (*Figs.* 22 and 23).—When a pyramid or cone is cut by a plane parallel to the base, the resulting lower part is a frustum. The volume of a frustum is the sum of the area of the top A_t, the area of the base A_b, and the square root of the product of A_t and A_b multiplied by one-third the height . . . . . . $(A_t + A_b + \sqrt{A_tA_b})\frac{h}{3}$

Sphere.—A round solid the surface of which at all points is equidistant from its centroid. Its volume is four-thirds of π multiplied by the radius cubed . . . . $\frac{4}{3}\pi r^3$

Surface Area of Sphere.—This is four times π multiplied by the radius squared . . . $4\pi r^2$

It is important to remember that if the linear dimensions are in inches the volume is in cubic inches, or if the linear dimensions are in feet then the volume is in cubic feet. If the dimensions are in inches it simplifies calculation to convert fractions of an inch to decimals of an inch so that the answer is in cubic inches ; if the dimensions are in feet and inches it is best to convert the inches to decimals of a foot so that the answer is in cubic feet (see *Table I*).

A problem that occurs in estimating is that of finding the cubic content of one linear foot. If the area of the cross section is multiplied by one linear foot we have the volume, which is numerically equal to the cross-sectional area, since multiplying by 1 or unity makes no change in the figures.

TABLE I.

Decimal Equivalents of Fractional Parts of an Inch															
Fraction	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
Decimal	0·063	0·125	0·188	0·25	0·313	0·375	0·433	0·5	0·563	0·625	0·688	0·75	0·813	0·875	0·938

Inches as Decimal Parts of a Foot											
Inches	1	2	3	4	5	6	7	8	9	10	11
0	0·083	0·167	0·250	0·333	0·417	0·500	0·583	0·667	0·750	0·833	0·917
1/4"	0·104	0·188	0·271	0·354	0·438	0·521	0·604	0·688	0·771	0·854	0·938
1/2"	0·125	0·208	0·292	0·375	0·458	0·542	0·625	0·708	0·792	0·875	0·958
3/4"	0·146	0·229	0·313	0·396	0·479	0·563	0·646	0·729	0·813	0·896	0·979

EXAMPLE 1.—Determine the cubic content of one linear foot of pre-cast concrete head course 4½ in. wide × 9 in. high as illustrated in *Fig.* 24.

Solution.—The cross-sectional area is $\frac{4{\cdot}5 \text{ in.} \times 9 \text{ in.}}{144} = 0{\cdot}28$ sq. ft. The cubic content is $0{\cdot}28 \times 1 = 0{\cdot}28$ cub. ft.

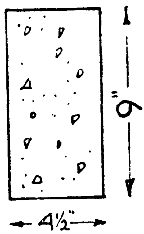


Fig. 24.

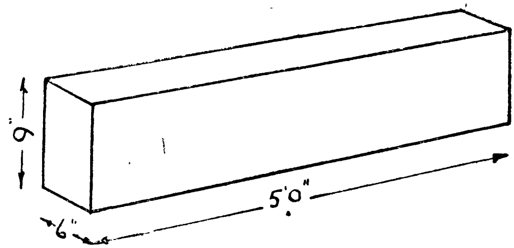


Fig. 25.

A very convenient method of arriving at the volume of one linear foot, which gives an approximate answer accurate enough for most estimates, can be done mentally. This is based on the fact that $\frac{1}{144}$ is approximately 0·007. If the cross section is squared in inches (which can usually be done on inspection) and then multiplied by 7 (which as a rule can also be done instantaneously), the answer is in decimals of a cubic foot. Care has to be taken in placing the decimal point. A few calculations, however, will soon show where to place it, and this method will be found of very great value for mental calculations.

EXAMPLE 2.—From Example 1 the area is 9 in. × 4½ in. = 40·5 sq. in.

Multiply by 7, and place the decimal point, and the volume is 0·283, which agrees closely enough with the more exact answer of 0·28.

EXAMPLE 3.—Determine the number of cubic feet in a concrete lintel (illustrated in *Fig.* 25) 6 in. wide × 9 in. high × 5 ft. long: (*a*) by the correct method, and (*b*) by the approximate method.

Solutions.—(*a*) The volume of 1 linear foot is

$$\frac{6 \text{ in.} \times 9 \text{ in.}}{144} = 0{\cdot}375 \text{ cub. ft.}$$

The volume of the 5-ft. lintel is 0·375 × 5 = 1·875 cub. ft.

(*b*) The cross-sectional area in inches is 54. The volume of 1 linear foot is 0·007 × 54 = 0·378. The volume of the 5-ft. lintel is

$$0{\cdot}378 \times 5 = 1{\cdot}890 \text{ cub. ft.,}$$

which agrees closely enough with the correct answer.

Many pre-cast concrete castings are in reality right prisms in that they have a constant cross section with an axis at right angles to the cross section, or, considered as a prism, to its base. In such cases it

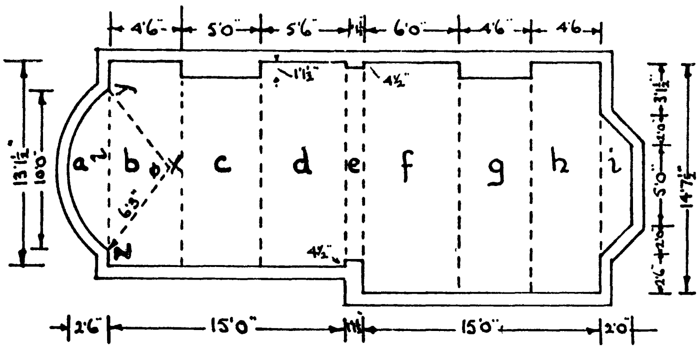


Fig. 26.

is only necessary to find the area of the cross section, and the volume can readily be found by multiplying by the required length. No hard and fast rules can be given to calculate areas of cross sections, because they are often made up of composite figures. The area of each simple part must be found by the formulæ already given, and their total is the required area. *Fig.* 26 is an example of a surface made up of a number of plane figures. The area is found by calculating separately the areas of the various parts and then taking their total, which in this case comprises a segment of a circle (*a*), rectangles of various sizes (*b*) to (*h*), and triangles and a rectangle (*i*).

CHAPTER IV

MEASUREMENT

THE procedure usually adopted in pricing bills of quantities is for the estimator to calculate a basic price per cubic foot for each item, which he usually notes on the left-hand side of the quantity sheet, and at the same time indicates whether the price is ex works or whether haulage is included. Attention is also drawn to sundries and reinforcement that may be required, and the calculations of unit price and extensions are then made. A slide rule is the most valuable instrument in an estimator's office, and skill in its use enables one to do in one hour what would otherwise take many hours. A comptometer machine simplifies calculation and saves much time compared with ordinary methods of calculation, but it is expensive in comparison with a slide rule. A slide rule, which for ordinary purposes is 10 in. long, is accurate to four significant figures only, but this degree of accuracy is sufficient for most estimating calculations. It is not satisfactory, however, as a means of extending pounds, shillings, and pence, for which a comptometer is accurate.

Methods of ascertaining the area, volume, weight, and cost of a variety of concrete units are given in the following examples. All calculations are by 5-in. slide rule. The accuracy of calculation for single castings need seldom be closer than three significant figures.

Surface Areas.

FLOOR AND WALL COVERINGS.

EXAMPLE 4.—*Fig.* 27 is a plan of a floor which is to be covered with terrazzo tiles. Calculate the area of tiling in square feet.

Solution.—The plan is split up into simple plane figures as indicated by A to G.

Part (A) is a segment and its area is the difference between the area of the sector bounded by zx and yx and the area of the triangle zxy. The sine of the angle lxz is $\dfrac{5}{6{\cdot}25} = 0{\cdot}8$. From tables, the angle lxz is $53°\ 08'$, and the angle θ is $2 \times 53°\ 08' = 106°\ 16'$.

The area of the sector is

$$\frac{106°\ 16'}{360} \times \pi(6{\cdot}25)^2 = 0{\cdot}29 \times \pi \times 39{\cdot}06 = 35{\cdot}58 \text{ sq. ft.}$$

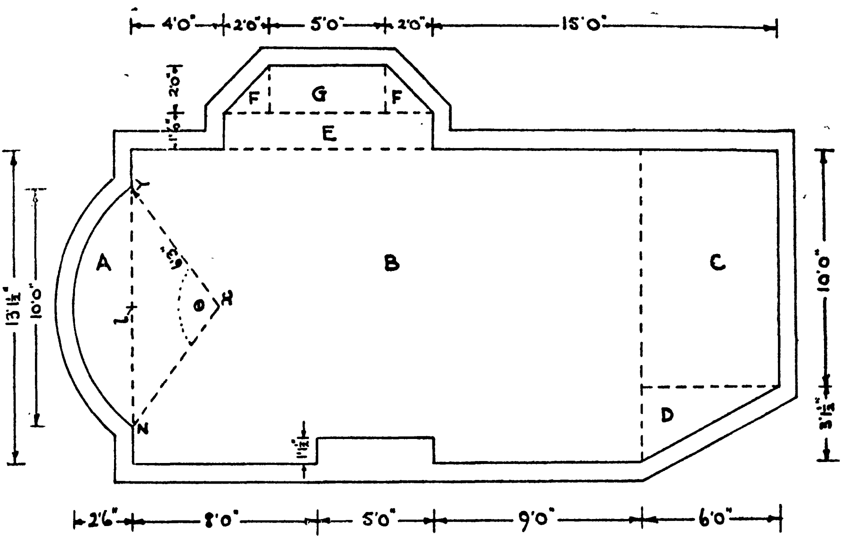


Fig. 27.

The area of the triangle *zxy*

$$= \frac{10 \text{ ft.} \times (6 \text{ ft. } 3 \text{ in.} - 2 \text{ ft. } 6 \text{ in.})}{2} = \frac{10 \text{ ft.} \times 3 \text{ ft. } 9 \text{ in.}}{2} = 18{\cdot}75 \text{ sq. ft.}$$

				Sq. ft.
Part *A*.	Area	$= 35{\cdot}58 - 18{\cdot}75$	=	16·8
Part *B*	,,	$= (22 \text{ ft. } 0 \text{ in.} \times 13 \text{ ft. } 1\tfrac{1}{2} \text{ in.}) - (5 \text{ ft. } 0 \text{ in.} \times 1 \text{ ft. } 1\tfrac{1}{2} \text{ in.})$	=	283·1
Part *C*	,,	$= 6 \text{ ft. } 0 \text{ in.} \times 10 \text{ ft. } 0 \text{ in.}$	=	60·0
Part *D*	,,	$= \tfrac{1}{2}(3 \text{ ft. } 1\tfrac{1}{2} \text{ in.} \times 6 \text{ ft. } 0 \text{ in.})$	=	9·4
Part *E*	,,	$= 9 \text{ ft. } 0 \text{ in.} \times 1 \text{ ft. } 6 \text{ in.}$	=	13·5
Part *F*	,,	$= \dfrac{2(2 \text{ ft. } 0 \text{ in.} \times 2 \text{ ft. } 0 \text{ in.})}{2}$	=	4·0
Part *G*	,,	$= 5 \text{ ft. } 0 \text{ in.} \times 2 \text{ ft. } 0 \text{ in.}$	=	10·0
			Total	396·8

Cost of Tiles and Polishing.

Example 5.—Find the cost per square foot of the tiles in Example 4, if the tiles are 1 in. thick and the basic price is 12*s.* per cubic foot unpolished and polishing takes 1¼ hours per square foot with wages at 1*s.* 9*d.* per hour.

Solution.—The basic price per square foot is

$\frac{1}{12} \times 1 \times 1 = \frac{1}{12}$ cub. ft. $\times$ 12*s.*	=	1*s.* 0*d.*
Polishing at $1\frac{1}{2}$ hours per square foot at 1*s.* 9*d.* per hour	=	2*s.* $7\frac{1}{2}$*d.*
Price per square foot of tile	=	3*s.* $7\frac{1}{2}$*d.*

Volumes and Costs of Rings.

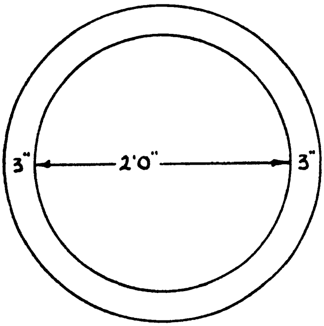


Fig. 28.

EXAMPLE 6.—(*a*) Find the cross-sectional area of the concrete pipe illustrated in *Fig.* 28.

(*b*) Calculate the price per linear yard if the basic price is 4*s.* 6*d.* per cubic foot.

Solution.—(*a*) The cross-sectional area is the difference between the areas of the outer and inner rings

$= \pi[(1 \text{ ft. } 3 \text{ in.})^2 - (1 \text{ ft.})^2] = \pi(1{\cdot}56 - 1) = 1{\cdot}76$ sq. ft.

(*b*) The volume of one linear yard is $1{\cdot}76 \times 3 = 5{\cdot}28$ cub. ft. The price per linear yard is $5{\cdot}28 \times$ 4*s.* 6*d.* = 23*s.* 9*d.*

Volumes and Costs of Hollow Units.

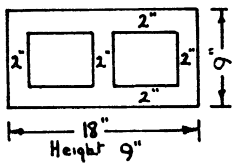


Fig. 29.

EXAMPLE 7.—(*a*) Calculate the volume of the hollow concrete block illustrated in *Fig.* 29.

(*b*) Find the number of blocks to a square yard of walling.

(*c*) Find the weight of a square yard of blocks if the concrete weighs 140 lb. per cubic foot.

Solution.—(*a*) The volume is

$(2 \times 18 \text{ in.} \times 2 \text{ in.} \times 9 \text{ in.}) + (3 \times 5 \text{ in.} \times 2 \text{ in.} \times 9 \text{ in.})$

$$= \left(2 \times \frac{324}{1728}\right) + \left(3 \times \frac{90}{1728}\right) = 0{\cdot}375 + 0{\cdot}156 = 0{\cdot}531 \text{ cub. ft.}$$

(*b*) The surface area of one face of a block is $1{\cdot}5 \times 0{\cdot}75 = 1{\cdot}125$ sq. ft.

The number of blocks per square yard of wall is $\frac{9{\cdot}0}{1{\cdot}125} = 8$.

(*c*) The weight of one block is $0{\cdot}531 \times 140 = 74{\cdot}3$ lb. The weight of a square yard of blocks is $74{\cdot}3 \times 8 = 594{\cdot}4$; say, 594 lb.

Rectangles and Frusta of Pyramids.

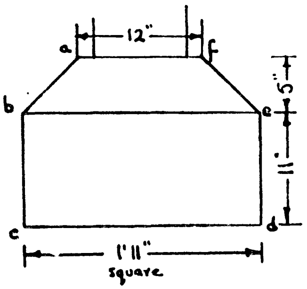


Fig. 30.

EXAMPLE 8.—Find the net volume of concrete in the foundation block illustrated in *Fig.* 30, and determine the weight if the concrete weighs 144 lb. per cubic foot.

Solution.—The volume of the base *bcde* is

$$1 \text{ ft. } 11 \text{ in.} \times 1 \text{ ft. } 11 \text{ in.} \times 11 \text{ in.}$$

Converting to decimals, this equals

$$1{\cdot}917 \times 1{\cdot}917 \times 0{\cdot}917 = 3{\cdot}36 \text{ cub. ft.}$$

The top part *abef* is the elevation of a frustum of a pyramid. Its volume is $(A_t + A_b + \sqrt{A_tA_b})\frac{h}{3}$

$$= \left\{(1 \text{ ft.} \times 1 \text{ ft.}) + (1{\cdot}917 \times 1{\cdot}917) + \sqrt{1 \times 3{\cdot}67}\right\}\frac{0{\cdot}417}{3}$$

$$= (1 + 3{\cdot}67 + 1{\cdot}917)\frac{0{\cdot}417}{3} = 6{\cdot}587 \times \frac{0{\cdot}417}{3} = 0{\cdot}916 \text{ cub. ft.}$$

Total volume is $3{\cdot}36 + 0{\cdot}92 = 4{\cdot}28$ cub. ft.
The weight is $4{\cdot}28 \times 144 = 616{\cdot}3$ lb.

Rectangles and Triangles.

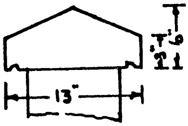


Fig. 31.

EXAMPLE 9.—Find the cost per linear foot of saddle-back coping, as illustrated in *Fig.* 31, in reconstructed stone at a basic price of 9*s.* per cubic foot. If haulage costs 12*s.* per ton, and the weight of the stone is 140 lb. per cubic foot, what is the extra for delivery?

Solution.—The Standard Method of Measurement measures a stone as the smallest rectangular block out of which it can be worked if it were natural stone.

The cost per linear foot is $\dfrac{13 \text{ in.} \times 6 \text{ in.}}{144} \times 9s. = 4s.\ 10\tfrac{1}{2}d.$

The number of cubic feet per ton is $\dfrac{2240}{140} = 16.$

The cost of haulage per cubic foot is $\dfrac{12s.}{16} = 9d.$

The net volume of 1 ft. of coping is

$$\frac{1}{144}\left\{(13 \text{ in.} \times 3 \text{ in.}) + \left(13 \times \frac{3}{2}\right)\right\} = \frac{39 + 19\frac{1}{2}}{144} = \frac{58\frac{1}{2}}{144} = 0{\cdot}406 \text{ cub. ft.}$$

The extra cost for delivery per linear foot is

$$0{\cdot}406 \times 9 = 3{\cdot}654d., \text{ say, } 3\tfrac{3}{4}d.$$

Rectangles and Pyramids.

EXAMPLE 10.—Find the number of pier caps illustrated in *Fig.* 32 to a full 6-ton load, if the weight per cubic foot is 140 lb. as in Example 9.

Solution.—The volume of the cap is

$$(1 \text{ ft. } 10 \text{ in.} \times 1 \text{ ft. } 10 \text{ in.} \times 4 \text{ in.}) + \left(1 \text{ ft. } 10 \text{ in.} \times 1 \text{ ft. } 10 \text{ in.} \times \frac{3 \text{ in.}}{3}\right)$$

$$= (1{\cdot}833 \times 1{\cdot}833 \times 0{\cdot}333) + \left(1{\cdot}833 \times 1{\cdot}833 \times \frac{0{\cdot}25}{3}\right)$$

$$= 1{\cdot}18 + 0{\cdot}28 = 1{\cdot}46 \text{ cub. ft.}$$

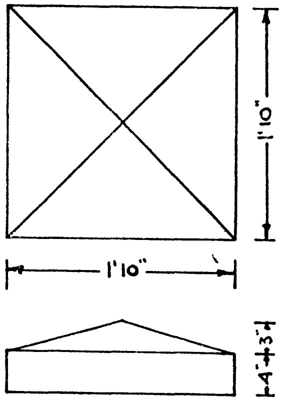


Fig. 32.

If there are 16 cub. ft. per ton, a full 6-ton load will require

$$16 \times 6 = 96 \text{ cub. ft.}$$

The number of pier caps requi.ed will be $\frac{96}{1{\cdot}46} = 66.$

Material Required to Fill a Mould.

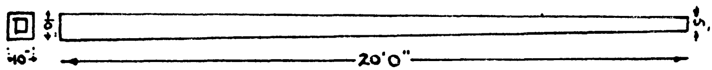


Fig. 33.

EXAMPLE 11.—Find the volume of loose materials required to fill the mould for the pylon illustrated in *Fig.* 33 if they occupy $1\frac{1}{3}$ more space than finished concrete.

Solution.—The pylon is a frustum of a pyramid. Its volume is

$$(A_t + A_b + \sqrt{A_t A_b})\frac{h}{3}$$

$$= \left[\left(\frac{5 \times 5}{144}\right) + \left(\frac{10 \times 10}{144}\right) + \sqrt{\frac{25}{144} \times \frac{100}{144}}\right]\frac{20}{3}$$

$$= (0{\cdot}174 + 0{\cdot}695 + \sqrt{0{\cdot}174 \times 0{\cdot}695})\ 6{\cdot}68$$

$$= (0{\cdot}174 + 0{\cdot}695 + 0{\cdot}348)\ 6{\cdot}68$$

$$= 1{\cdot}217 \times 6{\cdot}68 = 8{\cdot}15 \text{ cub. ft.}$$

The volume of loose materials required to fill the mould is

$$8{\cdot}15 \times 1{\cdot}33 = 10{\cdot}84 \text{ cub. ft.}$$

Surface Areas of Moulds.

EXAMPLE 12.—What is the surface area in contact with the mould if the pylon in Example 11 is made face down on the floor ?

Solution.—Three faces and two ends are in contact with the mould. The length of one face is $\sqrt{\left(\frac{2\frac{1}{2}}{12}\right)^2 + 20^2}$, but the difference from the height of 20 ft. is so small that it can be ignored.

The area of three faces is

$$0{\cdot}5 \times \left(\frac{10+5}{12}\right) \times 20 \times 3 = 0{\cdot}5 \times 1{\cdot}25 \times 60 = 37{\cdot}5 \text{ sq. ft.}$$

$$\text{Area of top} = \frac{25}{144} = 0{\cdot}174 \text{ sq. ft.}$$

$$\text{Area of base} = \frac{100}{144} = 0{\cdot}695 \text{ sq. ft.}$$

Total surface in contact with mould is

$$37{\cdot}5 + 0{\cdot}174 + 0{\cdot}695 = 38{\cdot}369 \text{ sq. ft.}$$

Volume and Weight of Arches.

EXAMPLE 13.—Find the weight of the cast stone voussoirs, keystone and surround bounded by the letters *a* to *j* of the arch illustrated in *Fig.* 34. The arch has a 9-in. bed. What would be the volume for estimating purposes if measured in accordance with Standard Method of Measurement ?

Solution.—The easiest way of calculating the volume is first to take the area of the parts *id, he, gf,* all at 12 in. deep, deduct the area of the arch *abk,* and multiply by the bed.

The length of *id* is 9 ft. 6 in. The area is 9 ft. 6 in. × 1 ft. = 9·5 sq. ft.

The length of *he* is 9 ft. 6 in. − 1 ft. 6 in. = 8 ft. The area is 8 ft. × 1 ft. = 8 sq. ft.

The length of *gf* is 9 ft. 6 in. − 4 ft. 6 in. = 5 ft. The area is 5 ft. × 1 ft. = 5 sq. ft.

The total area is 9·5 + 8·0 + 5·0 = 22·5 sq. ft.

The area of the two sectors ***alm*** and ***blm*** is

$$2 \times \frac{60}{360} \times \pi r^2 = 2 \times \frac{60}{360} \times \pi \times 1^2$$
$$= 2 \times \tfrac{1}{6} \times \pi = 1{\cdot}047 \text{ sq. ft.}$$

The area of the two figures ***lmkn*** is found by calculating the area of

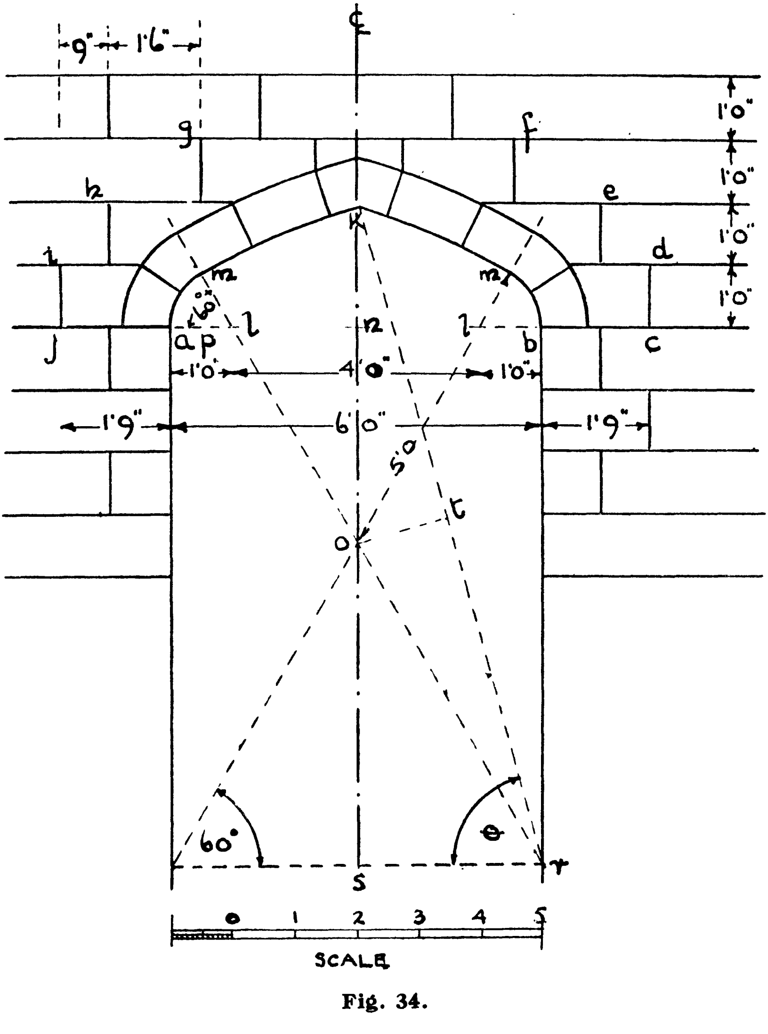


Fig. 34.

the sector *mrk* and deducting the area of the triangles *kor* and *lno* and multiplying by two.

The length *or* is $\dfrac{sr}{\cos 60^\circ} = \dfrac{3{\cdot}0}{0{\cdot}5} = 6$ ft.

The radius *mr* is 6 + 5 = 11 ft. $\text{Cos}\ \theta = \frac{sr}{kr} = \frac{3\cdot0}{11} = 0\cdot273$, and (from tables) this is an angle of 74° 09′.

The angle *mrk* is 74° 09′ − 60° = 14° 09′.

The distance *ot* is sin 14° 09′ × 6 = 0·2445 × 6 = 1·467 ft.

The distance *no* is 4 × sin 60° = 4 × 0·866 = 3·464 ft.

The area of the sector *mrk* is

$$\frac{14^\circ\ 09'}{360^\circ} \times \pi r^2 = 0\cdot0393 \times \pi \times 11^2 = 14\cdot95 \text{ sq. ft.}$$

The area of the triangle *kor* is $\frac{11 \times 1\cdot467}{2} = 8\cdot06$ sq. ft.

The area of the triangle *lno* is $\frac{2 \times 3\cdot464}{2} = 3\cdot46$ sq. ft.

The area of the two figures *lmkn*

$$= 2 \times [14\cdot95 - (8\cdot06 + 3\cdot46)] = 6\cdot86 \text{ sq. ft.}$$

The required area of voussoirs is 22·5 − (1·047 + 6·86) = 14·593 sq. ft., and the volume is $14\cdot59 \times \frac{9}{12} = 10\cdot95$ cub. ft.

If cast stone weighs 140 lb. per cubic foot the weight of the arch would be $\frac{10\cdot95 \times 140}{112} = 13\cdot7$ cwt.

As already stated, the Standard Method of Measurement measures a stone as the smallest rectangular block out of which it can be worked if it were natural stone. There is therefore no need to make any close calculations for measurements, scaling being sufficiently accurate.

The volume of cast stone in the arch is as follows :—

		cub. ft.
2/1 ft. 11 in. × 1 ft. × 9 in.	=	2·88
2/2 ft. 4 in. × 1 ft. 5 in. × 9 in.	=	4·95
2/2 ft. 1 in. × 1 ft. 8 in. × 9 in.	=	5·40
1/1 ft. 5 in. × 1 ft. 3 in. × 9 in.	=	1·32
	Total	14·55

CHAPTER V

MATERIAL QUANTITIES AND COSTS

THE volume of a casting can be found to any degree of accuracy, but a basic unit cost cannot be so accurately determined and presents variables in the form of labour charges in casting, fabricating steel, mould-making costs, and establishment charges. The cost of concrete materials which form part of the basic cost can, however, be calculated fairly accurately, and the quantities of various mixes when tabulated give a very quick method of arriving at their basic cost. It is advisable to calculate the price of a cubic yard of concrete, add for waste (usually about 5 per cent.), and then reduce to a price per cubic foot. Similar calculations are made in the case of mortar.

The difference between concrete and mortar is the aggregate of which they are composed. Aggregates which are retained on a $\frac{1}{4}$-in. screen are known as coarse aggregates, whilst aggregates which pass through are classified as " fines " or sand. The general meaning of mortar is a mixture composed of quarried sand, cement, and water, whilst concrete is a mixture composed of coarse aggregate and mortar. The proportions of a mix are specified for different purposes, and it is necessary to find the quantities of loose materials that make up a cubic foot or cubic yard of finished concrete.

The principles of proportioning are based on coating each particle of sand with cement paste, and surrounding each particle of coarse aggregate with mortar in such quantities that the voids in the resulting concrete are reduced to the minimum, consistent with a suitable strength. It is also necessary, owing to the greatly increased cost of cement over aggregates, to use no more cement than may be required to obtain a given strength, but this consideration of economy may be of no avail if the quantity of water is not also controlled.

Water Content.

It is well known that, so long as the proportions and other factors remain the same, concrete of considerable extra strength is obtained by keeping the cement-water ratio high. The modern method of consolidation by vibration makes it possible to use drier mixes in practically any form of construction. The pre-cast concrete manufacturer can, by the use of vibration tables, use concrete mixes with $\frac{1}{2}$ in. to 1 in. slump, which produce a concrete of almost maximum strength. If the produc-

tion is well organised labour charges should not be increased by vibration, but for some castings workability may be important, in which case it may be necessary to add more water. This, of course, has the immediate effect of reducing strength. A 1 : 1½ : 3 concrete made with about a ¾-in. slump and compacted by vibration has a 28-day crushing strength of 5000 to 6000 lb. per square inch. Such a concrete contains about 4 gallons of water per bag of cement, but if for purposes of workability 5 gallons of water per bag of cement are used, the strength is reduced to about 3500 lb. per square inch, and if 6 gallons of water are used the strength is about 3000 lb. per square inch.

It is obvious that with accurate water-cement control leaner mixes can be used than are ordinarily allowed, resulting in very great economies in cement without sacrifice of strength compared with wetter mixes containing the same proportion of cement.

Bulking of Sand due to Moisture.

Aggregates should be accurately measured by volume, and cement if possible should be weighed into the mixer hopper. If the sand supplied to the mixer is damp, it will be bulked. About 1 per cent. of moisture in sand will cause it to bulk several per cent., and increased quantities of moisture will cause bulking up to an amount of some 25 per cent. to 30 per cent. of the original dry sand volume. The effect of this may not at first be apparent, but the result, if not allowed for, will increase the consumption of cement, for if the specified mix is 90 lb. cement, 2 parts sand, and 4 parts aggregate, and the sand used is bulked by 25 per cent., the mix will in reality contain 90 lb. cement, 1½ parts sand, and 4 parts aggregate. In the former mix about 540 lb. of cement are used for a cubic yard of concrete, whilst in the latter mix 610 lb. of cement are used. The extra cost is that of 70 lb. of cement. The effect of the bulking of sand is still more important when mortar is used, as in concrete roofing tiles. When sand is completely saturated it occupies the same volume as dry sand.

The effect of bulking on coarse aggregates is very slight and from the point of view of estimating material costs can be ignored.

Volumes of Materials.

The most reliable method of arriving at quantities of materials for a given mix of concrete is based on absolute volumes. In a finished volume of concrete the actual amount of space occupied by the coarse aggregate, sand, cement, and water is calculated. The amount of space each loose material occupies in the finished concrete is obviously in the ratio of weight of loose material to its density, or specific gravity multi-

plied by the density of water. The specific gravity of cement is 3·14 and quarry sand and ballast have a specific gravity of 2·65. Granites and most stones have the same specific gravity as ballast. The specific gravity of lightweight materials should be ascertained in every case. The density of water is 62·4 lb. per cubic foot.

The weight of loose dry materials per cubic foot can readily be found by direct proportion of the weight of a known volume. For example, if the weight of loose dry sand contained in a 6-in. cubical box (one-eighth of a cubic foot) is $13\frac{1}{2}$ lb. the weight per cubic foot (W) is $\frac{1}{8} : 13\frac{1}{2} :: 1 : W$ from which $W = 13\frac{1}{2} \times 8 = 108$ lb. per cubic foot. Weighing loose sands and aggregates becomes very important in quantity calculations of stone facing materials, because sometimes the cost of these is almost that of cement.

The following example illustrates the procedure to arrive at the absolute volumes of material.

Example 14.—Ascertain the absolute volume of materials in a mix composed of 90 lb. cement, 2 parts loose dry sand weighing 108 lb. per cubic foot, and 4 parts $\frac{3}{8}$-in. ballast weighing 90 lb. per cubic foot if the mix is to contain 6 gallons of water, inclusive of the moisture in the sand and ballast.

Solution.— cub. ft.

$$\text{Cement} \quad \frac{90}{3{\cdot}14 \times 62{\cdot}4} = 0{\cdot}46$$

$$\text{Sand} \quad \frac{2 \times 108}{2{\cdot}65 \times 62{\cdot}4} = 1{\cdot}30$$

$$\text{Ballast} \quad \frac{4 \times 90}{2{\cdot}65 \times 62{\cdot}4} = 2{\cdot}16$$

$$\text{Water} \quad \frac{6 \times 10}{62{\cdot}4} = 0{\cdot}96$$

Absolute volume of finished concrete = 4·88

That is, 1 volume of cement (90 lb. loose = 1 cub. ft.) with 2 volumes of sand and 4 volumes of ballast mixed with 6 gallons of water, make 4·88 cub. ft. of finished concrete.

Quantities per Cubic Yard.

The number of times the quantities of the above mix are required to give a cubic yard is $\frac{27}{4{\cdot}88} = 5{\cdot}5$.

$$\text{Cement} \quad 90 \times 5{\cdot}5 = 495 \text{ lb.}$$

$$\text{Sand} \quad \frac{2 \times 5{\cdot}5}{27} = 0{\cdot}408 \text{ cub. yd.}$$

$$\text{Ballast} \quad \frac{4 \times 5{\cdot}5}{27} = 0{\cdot}816 \quad ,, \quad ,,$$

Note carefully that if the water is reduced to 5 gallons its absolute volume is $\frac{5 \times 10}{62{\cdot}4} = 0{\cdot}8$ cub. ft.

The total volume of finished concrete is then

$$0{\cdot}46 + 1{\cdot}30 + 2{\cdot}16 + 0{\cdot}8 = 4{\cdot}72 \text{ cub. ft.}$$

The revised quantities per cubic yard of finished concrete are

Cement	$\frac{27}{4{\cdot}72} \times 90$	$= 512$ lb.
Sand	$\frac{27}{4{\cdot}72} \times \frac{2}{27}$	$= 0{\cdot}423$ cub. yd.
Ballast	$\frac{27}{4{\cdot}72} \times \frac{4}{27}$	$= 0{\cdot}846$,, ,,

This shows the important effect that water has upon the quantities of materials. The water in the mix must include the moisture in the sand and ballast. If the weights are wanted, multiply the cubic yard figure by 27 and by the loose dry weight per cubic foot. In ordering and pricing materials which are delivered wet an allowance should be made for the loss of weight in comparison with loose dry materials. From Example 14 with 6 gallons of water in the mix the weights per cubic yard of finished concrete are

		lb.
Cement		495
Sand	$0{\cdot}408 \times 27 \times 108 =$	1190
Ballast	$0{\cdot}816 \times 27 \times 90 =$	1983
Water	$\frac{27}{4{\cdot}88} \times 0{\cdot}96 \times 62{\cdot}4 =$	332
		4000

The reduced weight per cubic foot is $\frac{4000}{27} = 148$ lb.

A concrete of the consistency in the example can only be compacted satisfactorily by vibration, and the apparent high weight of 148 lb. per cubic foot is to be expected. The 28-day strength of such concrete should be 5000 to 6000 lb. per square inch.

It will be noted that the water content affects the quantities of materials, as well as strength, but no standard ratio can be given because it varies with different mixes, becoming greater for leaner mixes.

Table II is based on good average results and can be relied on in estimating. No allowance for waste is made; this should be added

when computing prices. Where close supervision is maintained, waste can be reduced considerably, but generally it is wise to add 5 per cent.

TABLE II.—Quantities of Materials Required for 1 cub. yd. of Finished Concrete. The specific gravity of stone, ballast, and sand has been taken at 2·65 and cement at 3·14.

Proportions of Materials			STONE ½" and under Dust Screened out			BALLAST ¾" and under		
Cement	Sand	Coarse Aggregate	Cement lb.	Sand Cub. yd.	Stone Cub. yd.	Cement lb.	Sand Cub. yd.	Ballast Cub. yd.
1	1	2	970	·39	·78	870	·35	·74
1	1	2·5	860	·35	·88	790	·32	·80
1	1	3	775	·31	·94	710	·29	·86
1	1·5	2·5	770	·47	·78	690	·42	·73
1	1·5	3	700	·42	·84	640	·39	·78
1	1·5	3·5	650	·39	·91	590	·36	·83
1	2	3	640	·52	·77	580	·47	·73
1	2	3·5	590	·48	·83	540	·44	·77
1	2	4	550	·44	·89	505	·41	·81
1	2	4·5	510	·42	·93	470	·38	·86
1	2·5	4	510	·52	·82	470	·47	·75
1	2·5	4·5	480	·48	·87	440	·44	·80
1	2·5	5·0	450	·46	·91	410	·42	·83
1	3	4	480	·58	·77	430	·52	·72
1	3	4·5	450	·54	·81	410	·50	·75
1	3	5	420	·51	·85	390	·47	·78
1	3	5·5	400	·48	·89	365	·44	·81
1	3	6	380	·46	·92	350	·42	·84
1	3·5	5	400	·56	·80	360	·50	·76
1	3·5	6	360	·50	·87	330	·46	·80
1	3·5	6·5	350	·49	·91	310	·44	·82
1	3·5	7	330	·47	·93	300	·43	·85
1	4	7	310	·51	·89	290	·47	·81
1	4	8	290	·47	·93	270	·43	·86

Table III, for quantities of materials in mortar, is particularly useful in computing basic costs of cast stone. The water-cement ratio in a facing mix of about 4½ to 1 is $\frac{36}{90}$ by weight = 0·4, which requires 3·6 gallons of water, or 4½ gallons per 112-lb. bag of cement. The table is based on this water-cement ratio for a 1 : 3 mix and onwards.

TABLE III.—Materials Required for 1 cub. yd. of Mortar.

MIX	CEMENT lb.	SAND	
		Cub. yd.	TONS
1 : 1	1850	0·75	0·83
1 : 2	1240	1·1	1·1
1 : 2½	1050	1·15	1·17
1 : 3	900	1·15	1·2
1 : 3½	820	1·18	1·28
1 : 4	722	1·22	1·32
1 : 4½	680	1·26	1·36
1 : 5	630	1·3	1·41
1 : 5½	585	1·33	1·44
1 : 6	550	1·36	1·48

TABLE IV.—Specific Gravity of Natural Stone.

STONE	SPECIFIC GRAVITY
Bath Stone	1·96
Kentish Rag	2·6
Portland Stone	2·37
Sand stone	2·2
Limestone	2·65

The specific gravity has been taken as 2·5 in *Table* III, but more accurate calculations can be made by absolute volumes as already shown. The specific gravities of a few natural stones used in making cast stone are given in *Table* IV. The average weight per cubic foot of loose dry materials is 90 lb.

CHAPTER VI

PRICES

THE method of arriving at the price per cubic yard of concrete is to calculate the quantities of materials required, or obtain them from tables, and then multiply the various items by the prices per ton or cubic yard as the case may be. The prices of materials must include delivery to works, and allowance must also be made if the full value of sacks is not recoverable. If waterproofers, colours, accelerators, etc., are to be added to the mix, they are usually in proportion to the cement content and their prices can be calculated simply.

EXAMPLE 15.—If the price of Portland cement delivered works including non-recoverable bag charge is 56*s.* 6*d.* per ton, and ⅜-in. clean ballast and best washed sand are 12*s.* and 13*s.* per cubic yard respectively, what is the price per cubic foot of a 1 : 2 : 4 mix using ⅜-in. aggregate ?

Solution.—From *Table* II the quantities required for 1 cub. yd. are

	£	*s.*	*d.*
505 lb. Portland cement at 56*s.* 6*d.* per ton . .	0	12	9
0·41 cub. yd. sand at 13*s.* per cubic yard . . .	0	5	4
0·81 ,, ,, ⅜ in. aggregate at 12*s.* per cubic yard .	0	9	9
Price per cubic yard of concrete	1	7	10

and the price per cubic foot is

$$\frac{£1\ 7s.\ 10d.}{27} = 1s.\ 0{\cdot}4d.$$

If rapid-hardening Portland cement is to be used at an extra price of 6*s.* per ton the additional price per cubic foot is

$$\frac{505 \times 72}{2240 \times 27} = 0{\cdot}6d.$$

If quick-setting cement is used the extra cost must be calculated in the same way. If an accelerator such as calcium chloride is to be used the quantities do not generally exceed 1½ lb. per 112 lb. of cement.

If the price is, say, £12 per ton delivered at the works, then the extra cost per cubic foot to the 1 : 2 : 4 mix, given in Example 15, is

$$\frac{12 \times 240}{2240} \times \frac{90 \times 1\frac{1}{2}}{112} = 1{\cdot}56d.$$

using 1½ lb. of chloride per 112 lb. of cement.

Waste.

A good average figure to add for waste is 5 per cent., so that if, in Example 15, calcium chloride is to be added to the mix, the working price will be 1*s.* 0·4*d.* + 1·56*d.* = 1*s.* 1·96*d.* + 5 per cent. = 1*s.* 2·66*d.*, say, 1*s.* 2¾*d.* per cubic foot.

Transport Costs.

For every additional 1*s.* per cubic yard for delivery on the price of sand and ballast in Example 15, the extra per cubic yard is

0·41 cub. yd. sand
0·81 ,, ,, ⅜ in. aggregate

1·22 ,, ,, at 1*s.* = 1*s.* 2·6*d.* + 5 per cent. = 1*s.* 3·3*d.*

It is obvious therefore that, as ballast and sand together represent one of the biggest purchase items, it is essential to buy as cheaply as possible. This can best be done by establishing the products factory close to a pit. It may be that a contract is to be supplied some considerable distance from the factory, in which event the combined costs of transport of raw materials to the factory and the cost of transport of finished products to the site may represent a considerable sum. If there are suitable pits near the site arrangements may possibly be made for the manufacture of products on spare ground. Sometimes there may even be covered accommodation that can be leased at the pit, but at all events it will usually be found that considerable economies can be made by such arrangements and it is well worth while making enquiries. "The Concrete Year Book" has an up-to-date Sand and Aggregate section, reference to which will show the position of most pits. The section is arranged in counties so that no difficulty is experienced in arranging for supplies in any part of the country.

Facing Materials.

The quantities of materials are given in *Table* III, and the computation of prices is similar to that illustrated for concrete. If the sands used in the facing are cheap and the cement is the same as that of which the backing is composed, there will not be very great variations in the average price of facing and backing materials. Where, however, the facing sands are expensive, and white cement, which is very nearly four times the cost of ordinary Portland cement, is used, the cost of facing material is considerable. It is for this reason that a facing only, usually ¾ in. to 1 in. thick, with an ordinary concrete backing is used. There is no reliable average price to use in such circumstances, for the smaller

the cross section of a casting the greater becomes the price of materials per cubic foot, and similarly the price increases for every additional finished face. It is necessary to have figures handy for immediate reference when estimating, so that, having arrived at the prices per cubic foot of backing and facing, an analysis similar to *Table* V should be prepared, and then the results plotted graphically will show all the intermediate costs. For convenience any cross sections in general use are selected, and the cube calculations are based on 3-ft. lengths as this represents a good average. The results for one, two, and three faces are given, and if similar results are tabulated for the actual costs of a manufacturer's standard facings they will prove of inestimable value. Of course there is always bound to be a very slight error unless the particular section calculated in the table is being considered, but for average purposes they are most reliable, certainly vastly better than the many rule-of-thumb and total-average-cost methods often used.

In the case of repetition requirements of large sections it is always a good plan to make special calculations for the particular case.

Cost of Facings.

EXAMPLE 16.—If the current price of white Portland cement is £10 5*s*. per ton delivered, and the facing is made up of a mixture of sands, say, *A* at £1 15*s*. per ton, *B* at £2 5*s*. per ton, and *C* at 17*s*. 6*d*. per ton, and an assumed mix is made up of 1 part cement, 1 part *A*, 1 part *B* and 1½ parts *C*, the cost per ton, provided that the specific gravity and loose dry weight of each sand are the same, can be taken as the average :

		£	s.	d.
1	ton sand *A* at	1	15	0
1	,, ,, *B* at	2	5	0
1½	,, ,, *C* at 17*s*. 6*d*.	1	6	3
3½		5	6	3

The average cost per ton is $\dfrac{£5\ 6s.\ 3d.}{3\frac{1}{2}} = £1\ 10s.\ 4d.$

If the loose dry weight and specific gravity of the various sands are not the same the quantities should be worked out as shown in Example 14, and the separate price of each material should be calculated.

From *Table* III the quantities of material for a cubic yard of facing are

	£	s.	d.
820 lb. white cement at £10 5*s*. 0*d*. per ton . . .	3	15	0
1·28 tons sand at average price of £1 10*s*. 4*d*. . . .	1	18	9
	5	13	9

TABLE V.—Cost of Facings and Backings.

Section	Volume of Section 3'0" Long	Volume of Facing	Cost @ 4s.3d. cu.ft.	Volume of Backing	Cost at 1s.1d. cu.ft.	Total	Price per Cubic Foot
		ONE FACE 1" THICK					
	cu.ft.	cu.ft.	s. d.	cu.ft.	s. d.	s. d.	
6 × 2½	0·31	0·125	0-6·4	0·185	0-2·4	0-8·8	2s.4½d.
7 × 3½	0·51	0·146	0-7·5	0·364	0-4·7	1-0·2	2s.0d.
8 × 4	0·67	0·167	0-8·5	0·503	0-6·5	1-3·0	1s.10½d.
10 × 5	1·04	0·21	0-10·7	0·83	0-10·7	1-9·2	1s.8½d.
10 × 6	1·25	0·21	0-10·7	1·04	1-1·5	2-0·2	1s.7½d.
10 × 7	1·46	0·21	0-10·7	1·25	1-4·2	2-2·9	1s.6½d.
10 × 8	1·66	0·21	0-10·7	1·45	1-6·9	2-5·6	1s.6d.
12 × 12	3·0	0·25	1-0·8	2·75	3-0·0	4-0·8	1s.4½d.
12 × 24	6·0	0·25	1-0·8	5·75	6-3·0	7-3·8	1s.2¾d.
		TWO FACES 1" THICK					
			s. d.		s. d.	s. d.	
6 × 2½	0·31	0·156	0-8·0	0·154	0-2·0	0-10·0	2s.8d.
7 × 3½	0·51	0·198	0-10·1	0·312	0-4·1	1-2·2	2s.4d.
8 × 4	0·67	0·23	0-11·8	0·44	0-5·7	1-5·5	1s.11d.
10 × 5	1·04	0·29	1-2·8	0·75	0-9·8	2-0·6	1s.11½d.
10 × 6	1·25	0·31	1-3·8	0·94	1-0·2	2-4·0	1s.10½d.
10 × 7	1·46	0·33	1-4·8	1·13	1-2·7	2-7·5	1s.9½d.
10 × 8	1·66	0·36	1-6·4	1·30	1-5·0	2-11·4	1s.9¼d.
12 × 12	3·0	0·48	2-0·5	2·52	2-8·8	4-9·3	1s.7d.
12 × 24	6·0	0·73	3-1·3	5·27	5-8·5	8-9·8	1s.5½d.
		THREE FACES 1" THICK					
			s. d.		s. d.	s. d.	
6 × 2½	0·31	0·208	0-10·6	0·102	0-1·3	0-11·9	3s.2½d.
7 × 3½	0·51	0·27	1-1·8	0·24	0-3·1	1-4·9	2s.9d.
8 × 4	0·67	0·314	1-4·0	0·356	0-4·6	1-8·6	2s.7d.
10 × 5	1·04	0·395	1-8·2	0·645	0-8·4	2-4·6	2s.3½d.
10 × 6	1·25	0·44	1-10·5	0·81	0-10·5	2-9·0	2s.2½d.
10 × 7	1·46	0·48	2-0·5	0·98	1-0·8	3-1·3	2s.1½d.
10 × 8	1·66	0·52	2-2·5	1·14	1-2·8	3-5·3	2s.1d.
12 × 12	3·0	0·73	3-1·4	2·27	2-5·6	5-7·0	1s.10½d.
12 × 24	6·0	1·23	5-2·8	4·77	5-2·2	10-5·0	1s.9d.

Each additional square foot of face costs 1/12 of 4s.3d. = 4·25d. minus 1/12 of backing @ 1s.1d. cu.ft. = 1·1d. = 3·15d., say 3d. sq. ft.

and the price per cubic foot is $\frac{£5\ 13s.\ 9d.}{27} = 4s.\ 2{\cdot}6d.$, say, 4*s.* 3*d.* per cubic foot.

If the cost of backing is taken at 1*s.* 0·4*d.*, say, 1*s.* 1*d.* per cubic foot as calculated in Example 15, then the price of materials of cast stone varies from the smallest sections which would be almost solid facing at 4*s.* 3*d.* per cubic foot to large sections which would have a relatively small proportion of facing and the material price of which would be nearer the concrete backing cost of 1*s.* 1*d.* per cubic foot.

Effect of Volume on Basic Cost.

Table V and *Fig.* 35 show the results of the combined facing and backing costs, from which it will be noted that the greater the volume the less the basic cost. This is of the utmost importance because all labour and mould charges vary in a similar manner, so that when eventually all the costs are co-ordinated in one basic price the rate of variation is considerable.

In drawing the graph on *Fig.* 35 it may happen that some of the prices per cubic foot may fall outside the line required to form a good regular curve. The reason for this will probably be due to a too rapid change in choice of sections, when the ratio between facing and backing is very much greater than those on either side of it. The object is to get a good curve which will represent good averages. If the curve does not pass through all the points, it should be so constructed that an equal number of points lie on either side of the curve.

Table VI is prepared from the graph in *Fig.* 35 and gives the prices per cubic foot for cast stone materials. Under 0·3 cub. ft. volume per unit the casting would probably be solid facing, so that the price per cubic foot is 4*s.* 3*d.* Variations of one-tenth of a cubic foot are tabulated up to 1½ cub. ft., then the rate of change of price is much less and the price for each whole cubic foot up to six is tabulated, at which price the material cost cannot be reduced much more.

Mould Oil.

In the semi-dry process of making cast stone it is not necessary to use mould oil, but for semi-wet and wet casting its use is essential. It is rather an indeterminate charge and, being a very small item, is best ignored as a direct charge and included in overhead charges, so that the total annual cost of mould oil is distributed over the total production of semi-wet and wet castings.

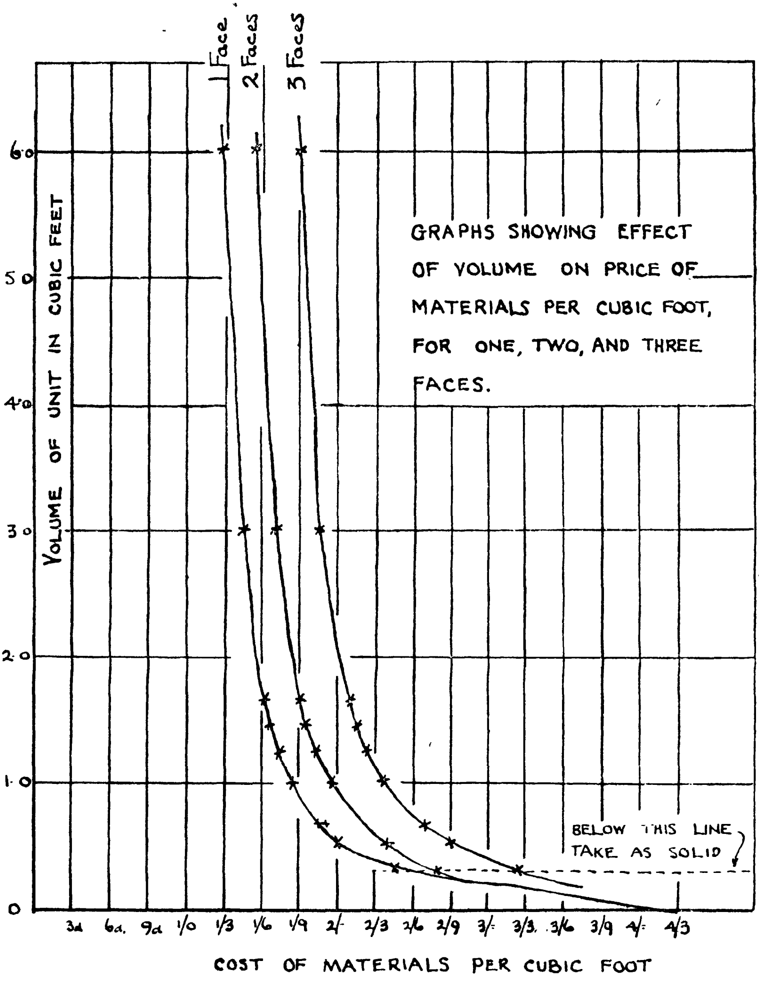


Fig. 35.

Pigments.

The proportions of coloured pigments are usually specified by percentage in relation to cement content, and as very small quantities affect the degree of colour considerably it is a good practice always to add pigment by weight. The quality of pigments varies considerably, many of the cheaper grades being adulterated with chalk. As a rule

TABLE VI.—Cost of Facings per Cubic Foot.

	UNIT VOLUME (cu. ft.)																		
	UNDER 0·3	0·3	0·4	0·5	0·6	0·7	0·8	0·9	1·0	1·1	1·2	1·3	1·4	1·5	2·0	3·0	4·0	5·0	6·0
ONE FACE	4s.3d.	2s.6d	2s.2½d	2s.0d.	1s.11d.	1s.10½d	1s.9½d.	1s.9d.	1s.8½d.	1s.8d.	1s.7½d	1s 7d	1s.7d.	1s.6½d	1s.5½d	1s.4½d	1s.4d.	1s.3d.	1s.3d.
TWO FACES	4s.3d.	2s.8d.	2s.5½d	2s.4d.	2s.3d.	2s.2d.	2s.1d.	2s.0d.	1s.11½d	1s.11d.	1s.10½d	1s.10d	1s 9½d	1s.9½d	1s.8½d.	1s.7d	1s 6½d	1s.6d.	1s.5½d.
THREE FACES	4s.3d.	3s.3d.	3s 0d.	2s.10d	2s.8d	2s.6½d	2s 5½d	2s.4½d.	2s.4d	2s 3d.	2s.2½d	2s 2d	2s.1½d	2s 1½d.	2s.0d.	1s.10½d	1s.10d.	1s.9½d	1s.9d.

For additional fair faces add 3d square foot

the best are practically 100 per cent. pure pigment, but the price is high in comparison with the adulterated mixtures; pure pigments are, however, cheaper in the long run, as much less is required. In the majority of cases the manufacturer uses his own knowledge, or finds by experiment the quantity of pigment required to attain certain results. The calculation of the price is simple.

EXAMPLE 17.—A cast stone facing is to be made up of a mix of $4\frac{1}{2}$ parts sand the average price of which is 25*s.* per ton, and 1 part Portland cement at 56*s.* 6*d.* per ton; 3 per cent. of pigment by weight of cement is to be added to the mix. The pigment costs 1*s.* per lb. What is the cost per cubic foot of materials for such a mix?

Solution.—From *Table* III the quantities of materials are

	£	*s.*	*d.*
680 lb. cement at 56*s.* 6*d.* per ton	= 0	17	2
1·36 tons sand at 25*s.* per ton	= 1	14	0
3 per cent. of 680 = 20·8 lb. pigment at 1*s.* per lb.	= 1	0	10
Cost per cubic yard	3	12	0

The price per cubic foot is $\frac{£3\ 12s.\ 0d.}{27} = 2s.\ 8d.$

In this example the price of pigment per cubic yard of concrete is greater than the cost of cement. This is seldom the case, however, and the reason the price has been kept high is to illustrate what effect pigments can have on cost. For pigment only the cost per cubic foot is $\frac{20s.\ 10d.}{27} = 9{\cdot}3d.$ nearly. Actually some pigments cost more than 1*s.* per lb. when manufactured to the specification of the Cast Concrete Products Association. These include some shades of green, chrome yellows, vermilion, and blue. The more common reds and buffs in very reliable brands cost only a few pence a pound.

There is also a British Standard Specification (No. 1014, 1942) relating to "Pigments for Colouring Cement and Concrete."

CHAPTER VII

LABOUR COSTS

As has previously been mentioned, labour costs are a variable, being very high per cubic foot for small sections and rapidly decreasing as the section and volume increase. Although the cost per cubic foot is high for small sections, the labour cost per unit or article reduces with reduction of volume. It is sometimes said that a unit of ½ cub. ft. costs as much to make as a unit of, say, 1½ cub. ft. Up to a point this is true. The labour costs of stripping the mould and reassembling it, handling to curing chambers and stacking ground, and loading on to lorries become almost a constant up to the point where a minimum of labour can be employed. Beyond a certain weight and bulk more men must be employed or mechanical equipment used, which then increases costs. Mixing and placing costs, for plastic concrete, are, however, almost directly proportional to the volume. It will be realised, therefore, that labour charges will vary from a minimum price per unit to a price almost equivalent to that of placing mass concrete. If, for example, a unit of, say, 0·5 cub. ft. costs in labour 1*s.* 3*d.* and a unit of, say, 6 cub. ft. costs in labour 3*s.*, the comparison of basic prices is as follows:

0·5 cub. ft. costs 1*s.* 3*d.*,	∴	1 cub. ft. costs	2*s.* 6*d.*
6·0 ,, ,, cost 3*s.*	∴	1 ,, ,, ,,	6*d.*

The respective costs on a basis of 1 cub. ft. are therefore 2*s.* 6*d.* per cubic foot in the case of a unit of 0·5 cub. ft. and 6*d.* per cubic foot when a unit has a volume of 6 cub. ft.

The advantage of working basic costs in cubic feet is that data can be compiled and used conveniently for estimating, whereas estimating cast stone and general concrete products by unit costs is a very cumbersome process, necessitating lengthy calculations in every case.

There are cases, however, when very large quantities of a special casting of unusual shape may be more easily priced by computing the separate estimates of cost on a unit basis. When factories specialise in one or two standardised mass-produced products, such as blocks, slabs, paving flags, and pipes, their entire wages can be easily apportioned to the respective products, so that the labour charges are easily calculated. The following sections, however, deal almost exclusively with an outline of a method devised for pricing practically any form of concrete product which is hand made in separate moulds.

Basis of Costs.

Because wages vary in all parts of the country, and the district rates themselves rise and fall, any costs produced in cash values are liable to become obsolete very quickly. The cost can, however, be stated on a time basis, such as 45 minutes per cubic foot. This means that if the district rate is 1*s*. 6*d*. per hour and the time per cubic foot is 45 minutes, then the price of labour per cubic foot is $\frac{45}{60} \times 18 = 1s.\ 1\frac{1}{2}d.$ The time rate of minutes per cubic foot is in some cases, in the following chapters, abbreviated to "m.p.c."

CHAPTER VIII

LABOUR IN MIXING

MIXING concrete can be done by hand or by machine. If a mechanical mixer is not available and the quantity of concrete required is small, the materials can be mixed by hand. Hand-mixed concrete is not usually as strong as machine-mixed concrete, and most specifications require an additional 10 per cent. of cement to be used when concrete is mixed by hand. Under most conditions it is preferable to employ a mechanical mixer, because the labour charges are reduced considerably. Small machines can be moved about in the works easily or mixed concrete can be transported by barrow or truck from the nearest mixer.

Hand Mixing.

If hand mixing is adopted the materials should be assembled around a mixing board with a watertight surface, which can be of wood or lined with sheet metal. The cement and sand are first mixed together to an even colour and then spread out a few inches thick over the board. The coarse aggregate is then carefully measured and spread over the top of the mixed sand and cement. The batch is then thoroughly turned over, a minimum of four times or until the colour is uniform being a good rule. Then the mixed materials are piled into a conical heap and a hollow is made in the top, in which water is added gradually through the rose of a watering can or the spray nozzle of a hose. The batch is turned until the pile is of the consistency required throughout. Sometimes the mixed sand and cement are made into mortar before the coarse aggregate is added; both methods are satisfactory, provided that the materiais are well turned to ensure that all particles of aggregate are covered with mortar.

The time of mixing concrete by hand when quantities of about 1 cub. yd. at a time are being mixed is a total of $4\frac{1}{2}$ hours. If the labourer's rate is 1*s.* 6*d.* per hour the mixing cost will be

$$4\tfrac{1}{2} \times 1s.\ 6d. = 6s.\ 9d. \text{ per cubic yard,}$$

or 3*d.* per cubic foot.

The mixing of mortar takes rather longer, and 6 hours should be allowed per cubic yard.

Machine Mixing.

Hand mixing is practically out of date in products factories, as machines do the work very much more efficiently and at greatly reduced cost. Standard mixers are graded 5/3, 7/5, 10/7, 14/10, and so on. The first figure indicates the maximum batch of loose materials, and the latter the output of concrete, in cubic feet. A mix takes one minute to $1\frac{1}{2}$ minutes after the materials have been assembled in the drum. The length of the time of mixing has an important effect upon the strength, a two-minute mix giving a stronger concrete than that mixed for one minute. Having decided on the time of mix the output from a mixer of any size can be calculated. Allowing for loading and discharging the mixer, it is possible to get a batch at about 4-minute intervals, but this can only be maintained if the batch is immediately discharged into a concrete storage hopper or into waiting barrows or trucks.

Assuming adequate arrangements are made for immediate disposal of a batch, the number of mixings per hour from a 7/5 mixer would be $\frac{60}{4} = 15$ batches or, in an 8-hour day, $8 \times 15 = 120$. The mixed concrete has a volume of 5 cub. ft. per batch, and the daily output would be $120 \times 5 = 600$ cub. ft. This is an ideal arrangement, but in practice is seldom achieved in a products factory because the mixed concrete cannot be taken away quickly enough. The reason is that concrete is taken to the making area by barrow and, depending on the size of the unit being cast, the barrow of concrete may not be used up for half an hour. Since the making space around a mixer, usually permanently installed, is limited, the output is controlled by the rate at which the concrete can be used.

In such conditions a good average time to allow for mixing in a 7/5 mixer is 2 minutes per cubic foot, which includes all labours of getting materials from stock piles, not exceeding 50 ft. away, charging hopper, mixing and discharging, and cleaning the mixer at the end of the day (usually about half an hour). Carting away is not included, however, this being done by the caster's labourer, the cost of which is included in the making time, which is given later. As a matter of interest, however, on a level site, concrete can be wheeled in an average wheelbarrow at a rate of about 200 ft. per minute. On an inclined surface the speed is about 1 per cent. less for every 1 deg. of inclination. Cement and aggregates are wheeled at much the same rate.

Economies in Mixing Costs.

It has been mentioned that in ideal conditions a batch of concrete could be produced from a mixer in 4 minutes. The average time per batch working on average factory conditions in the case of a 7/5 mixer is $5 \times 2 = 10$ minutes. In the first case 600 cub. ft. of concrete are produced in 8 hours, whereas a 10-minute average mix will only produce $\frac{60}{10} \times 5 \times 8 = 240$ cub. ft. It is immediately obvious that, provided production warrants it, an efficient system of delivering materials to mixer, mixing, discharging, and taking away, each process timed by the maximum rate at which the mixer can operate, will result in considerable reduction of cost.

Such a scheme, however, is not worth considering unless it can be seen that the production of castings will absorb the concrete at the speed at which it is produced. In the most suitable type of mixing plant for pre-cast concrete, the cement, sand, and aggregates are mechanically elevated by skip to the mixer, and the mixer is at a sufficient height to allow the concrete to be discharged into a storage hopper, or direct into trucks.

EXAMPLE 18.—What is the cost of mixing per cubic foot if the average time taken is 2 minutes per cubic foot? The mixer driver's rate is 1*s*. 8*d*. per hour.

Solution.—The cost is $\frac{2}{60} \times 20 = \frac{40}{60} = \frac{2}{3}d.$ per cubic foot.

The cost is very little, and a separate calculation as in Example 18 is seldom necessary as the time rate is added to the manufacturing estimate of cost described later on.

An important point to remember is that casting costs vary with the volume of the article in a similar way to facing material costs previously described, but concrete mixing costs remain practically a constant, varying only by reason of fluctuating output, but it is impossible to estimate this in advance. The figure of 2 minutes a cubic foot is a good and safe average.

EXAMPLE 19.—If a batching plant is capable of producing a 4-minute batch throughout 8 hours, and a 14/10 mixer is used, what is the labour cost per cubic foot of mixing, if the driver's rate is 1*s*. 8*d*. per hour, the plant being operated by one man?

Solution.—The number of batches produced is $\frac{60}{4} \times 8 = 120$ per day. The output in each batch is 10 cub. ft. and the total output is

$120 \times 10 = 1200$ cub. ft. Driver's wages are $8 \times 1s.\ 8d. = 13s.\ 4d.$ Cost per cubic foot for mixing $= \dfrac{13s.\ 4d.}{1200} = 0{\cdot}13d.$

EXAMPLE 20.—What is the annual saving in a products factory producing 1200 cub. ft. a day by operating a plant as in Example 19 in preference to the general mixing methods adopted in Example 18?

Solution.—The cost of mixing in Example 18 is 0·66
„ „ „ „ „ „ 19 „ 0·13

The saving is . . . . . 0·53*d*. per cub. ft.

The total production is $1200 \times 5\frac{1}{2} = 6600$ cub. ft. per week.
The annual production is $6600 \times 52 = 343{,}200$ cub. ft.
The annual saving is $343{,}200 \times 0{\cdot}53d. =$ £757 18*s*.

Indirect Labour Charges.

Under this heading are charges that cannot always be directly apportioned to any particular process of manufacture. They include:

(1) UNLOADING INCOMING MATERIALS.—Many of the items are practically indeterminable, and the combined costs in an analysis of wages represent a very small percentage.

A few examples of times for unloading are:

	Man-hours.
(*a*) 6-ton load of cement in 1-cwt. bags	2
(*b*) Ballast if delivered by tipper	Nil
(*c*) 6 tons of aggregate unloaded by shovel	$1\frac{1}{2}$
(*d*) 6 tons of bar reinforcement in long lengths, bundles not exceeding 2 cwt.	7
(*e*) 1 load of timber, approximately 2 standards, including stacking	12

(2) STACKING AND LOADING.—The cost of this item is likely to vary, depending upon whether it is all done by hand or crane, and the accessibility of vehicles and trucks to the stacks and stacking sites.

(3) GENERAL LABOURS.—All workers who are not otherwise classified, or whose time is divided between many different jobs so that the calculation of separate times is involved, are included under this heading. Examples are labourers' time in sweeping and cleaning yard; clearing sites for making; collecting and returning moulds to and from mould shop; attending to fires, boilers, etc.

(4) FITTERS.—This item is included in indirect charges if the main-

tenance work is executed on the premises. Where facilities do not exist for this work to be carried out on the premises, the item is included in overhead charges.

(5) WATCHMEN.—This item is an indirect charge when men are employed for this purpose.

(6) FOREMEN AND STOREKEEPER.—This item is sometimes included in establishment charges, but it is convenient to classify it with indirect charges, because then in any period of time the percentage allowed for these charges can be added to the direct wages, thus making it possible to compare the estimated wages with the actual wages recorded in the wages book.

(7) LOST TIME.—Payment for time lost due to inclement weather has to be made in most factories under an Act of 1941, and little experience exists as to what is a fair margin to allow. Frost is the chief concern, but as rapid-hardening cement and calcium chloride can be used safely in temperatures down to about 32 deg. F., and some work can be continued by the addition of hot water and by the use of steam and braziers, this item alone should not exceed 5 per cent. on direct charges.

(8) HOLIDAYS.—In 1939 a law was passed which entitled all workers to a paid holiday of a minimum of half a day for every month of service. This item also represents an indirect charge on wages.

Most of these charges vary with the volume of a casting in a similar way to direct charges shown in Chapter IX, and for this reason it is convenient to work on a percentage basis, the additions being made to the minutes per cubic foot basis given later.

A good average figure to add to direct charges to cover the items (1) to (8) is 43 per cent. It should be borne in mind that moulders' labourers are included as a direct charge, and mixing is added as a constant figure.

CHAPTER IX

LABOUR CHARGES IN CASTING

A NUMBER of processes affect the cost of casting concrete products and cast stone, and because these vary, and different manufacturers have their own ideas on the most suitable process or combination of processes to adopt, no hard-and-fast rules can be laid down with any degree of accuracy on what any process will cost. The most commonly used process for concrete products is wet casting, and, for cast stone, the semi-dry process. The various manufacturing methods are:

(1) Machine casting by pressure, jolting, and tamping;
(2) Casting by the plastic process on vibrating tables;
(3) Wet casting;
(4) Semi-dry casting (tamping);
(5) Centrifugal spinning.

Of these processes wet casting is the cheapest provided the amount of repetition warrants a number of moulds, as each casting has to be left in the mould for a minimum of 24 hours. Steam curing, however, can be employed so as to strip castings about every 4 hours. Consolidation by vibration is now receiving a great deal of attention and, with the assistance of steam, enables a very great increase in production to be maintained. The process is slightly more costly from a casting point of view, but it is important as, with correct water control, concretes of almost maximum strength can be obtained.

In estimating for products cast in machines the manufacturer's estimate of output should always be obtained. As a rule these are given for working under ideal conditions, and until, from experience, one knows the actual output that can be maintained, it is advisable to be on the safe side in assessing output. A semi-dry concrete is most generally adopted, and a pan mixer will give the most consistent mix. The operation of a pan mixer takes slightly longer than a revolving-drum type, and if the concrete is not delivered from a central batcher the mixing time should be calculated, as the production of the block machine will be known, and if a pan mixer is used to supply it the daily output can be gauged exactly.

EXAMPLE 21.—A machine can produce 500 18 in. × 9 in. × 3 in. blocks in 8 hours. One man is employed on the mixer at 1*s.* 7*d.* per hour, one on operating the machine at 1*s.* 7*d.* per hour, and a labourer for carrying blocks to drying racks at 1*s.* 5*d.* per hour. What is the total labour cost per square yard?

Solution.—The volume of concrete required in a day is

$$\frac{18 \times 9 \times 3}{1728} \times 500 = \text{say, } 140 \text{ cub. ft.}$$

If a 5/3 pan mixer is used the number of batches is $\frac{140}{3} = 47$ (approximately in 8 hours, or 6 batches an hour). As the pan is to be charged by shovel this is a fair average, but, with another man on the mixer, two block machines could be fed. This figure should always be calculated as a guide to the number of men required on the mixer.

	£	s.	d.	
Mixing cost is 8 × 1*s.* 7*d.*	= 0	12	8,	i.e. 3½ m.p.c.*
Making cost is 8 × 1*s.* 7*d.*	= 0	12	8	
Labourers cost is 8 × 1*s.* 5*d.*	= 0	11	4	
	1	16	8	
Add for indirect labour charges, 43 per cent.	0	15	9	
	2	12	5	

There are 8 blocks per square yard and the cost is

$$\frac{\pounds 2\ 12s.\ 5d.}{500} \times 8 = 10d. \text{ per square yard.}$$

Caution should be exercised in estimating the correct number of operators in a gang. For instance, it is useless producing blocks faster than they can be carried away if only one labourer is employed. Either two labourers should be employed, which may mean that neither is fully employed, or the production should be reduced within the carrying limit of one labourer. One man cannot carry continually, over a period of 8 hours, weights much above 60 lb. without fatigue.

Example 21 is typical of the method of compiling labour estimates of machine-made articles. The estimate is usually per block, or per square yard of blocks, but in the majority of labour estimates of concrete products and cast stone a basic cost per cubic foot is ascertained.

As a general rule the smaller a casting is made, the cheaper it becomes when priced at per unit, but unit calculations are seldom made when pricing a general bill of quantities, the basic cost being based on a price of a cubic foot. On the basis of cost per cubic foot, however, the smaller a casting is made the greater becomes the cost and, as has been previously illustrated, if the labour cost of a unit of 0·5 cub. ft. is 1*s.* 3*d.* the price per cubic foot is 2*s.* 6*d.* A unit of 6 cub. ft. that costs 3*s.* to cast, only represents 6*d.* a cubic foot.

* Minutes per cubic foot.

If men work conscientiously the various casting costs vary in such a manner that (*a*) when the castings are large the costs approach the basic cost of placing mass concrete, and (*b*) when they become smaller they approach the minimum cost of making a unit. For example, the cost of casting the smallest unit of, say, ¼ cub. ft. volume might be very

TABLE VII.—Average Times for Placing Concrete.

UNIT VOLUME (CU. FT.)	MINUTES (BASED ON 15 M.P.C.)	MINUTES BASED ON $30 - \frac{15}{2} = 22\frac{1}{2}$ say 23 per unit	TOTAL MINUTES PER CASTING	MINUTES PER CUBIC FOOT
0·3	4·5	23	27·5	92
0·4	6·0	23	29·0	73
0·5	7·5	23	30·5	61
0·6	9·0	23	32·0	53
0·7	10·5	23	33·5	48
0·8	12·0	23	35·0	44
0·9	13·5	23	36·5	41
1·0	15·0	23	38·0	38
1·1	16·5	23	39·5	36
1·2	18·0	23	41·0	34
1·3	19·5	23	42·5	33
1·4	21·0	23	44·0	32
1·5	22·5	23	45·5	30
2·0	30·0	23	53·0	27
3·0	45·0	23	68·0	23
4·0	60·0	23	83·0	21
5·0	75·0	23	98·0	20
6·0	90·0	23	113·0	19
7·0	105·0	23	128·0	18
8·0	120·0	23	143·0	18

Based on simple plain wet castings in wood moulds

little per cubic foot, but the charges for stripping and cleaning the mould, stacking, loading, etc., become comparable with all units up to a volume of, say, 2 cub. ft., and it is these charges which directly control the minimum price of a unit.

The average time for placing concrete, including all general labours other than those previously enumerated under indirect charges, for large castings is 18 minutes per cubic foot, and the average time to make a small unit of about 0·5 cub. ft. is 30 minutes, when the castings are plain unreinforced concrete made in wood moulds which have to be stripped, and the quantity required does not enable mass-production methods to be employed.

Castings which can be made with slightly tapered sides cost very much less to produce if the moulds are constructed in such a manner that by being inverted the casting is released, thus avoiding the dismantling of the mould. The effect of such economies, however, can only be judged by experience. For instance, pre-cast concrete kerbs made in steel moulds that are instantaneously released can be produced at about 15 minutes per cubic foot.

When reinforcement cages are embedded in the castings the extra labour in placing is approximately 10 per cent. Complicated mould assembly can cost as much as 25 per cent. more, but such cases are best dealt with as they arise.

If large castings are to be made the time rate of manufacture does not vary very much, as will be noted in *Table* VII, for volumes of 4 to 8 cub. ft. The time rate, however, for units up to 3 cub. ft. varies very rapidly, and *Fig.* 36 is typical of the rate of change for small units.

All concrete labour costs, no matter what type of casting is being produced, when plotted in graph form have the general outline of *Fig.* 36. The author has compiled statistics which show the accuracy of such a graph. It is interesting to note that there is a relation between the minimum cost of casting and the unit cost, and practically any costs can be pre-determined mathematically, provided that a casting time per cubic foot can be set for large units, and a unit time for small castings of, say, 0·5 cub. ft. In the case of plain unreinforced concrete castings, the minimum time for casting is about 15 m.p.c. The minimum unit casting time is 30 minutes for a unit of 0·5 cub. ft. If allowance is made on the small unit for the time rate in casting per cubic foot, the time is $30 - \frac{15}{2} = 22\frac{1}{2}$, say, 23 minutes per casting. The casting time of a unit of any size, provided it is plain and has no complications in mould stripping and assembly, will be found to be the volume multiplied by 15 m.p.c. plus 23. *Table* VII is compiled for

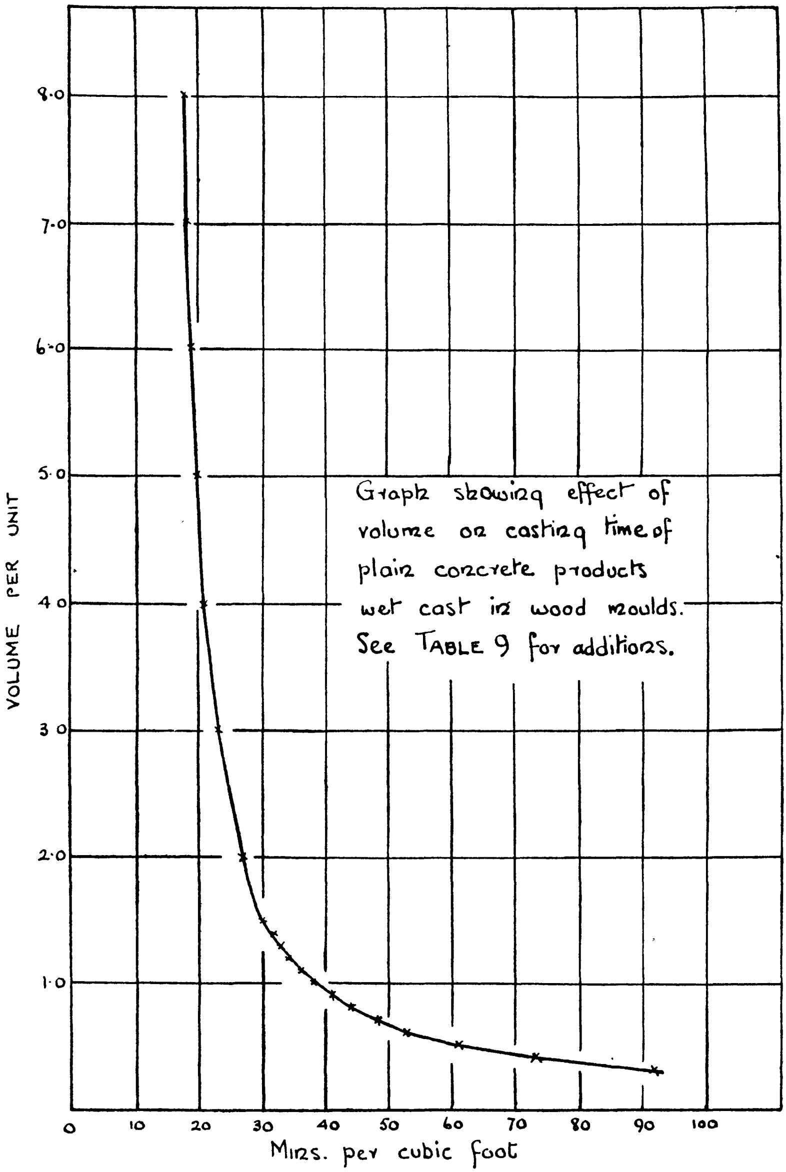

Graph showing effect of volume on casting time of plain concrete products wet cast in wood moulds. See TABLE 9 for additions.
VOLUME PER UNIT
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0
10
20
30
40
50
60
70
80
90
100
Mins. per cubic foot

Fig. 36.

volumes from 0·3 cub. ft. increasing by one-tenth of a cubic foot to 1·5 cub. ft. and then by increases to the next whole cubic foot up to 8. In the last column the minutes per casting are expressed on a basis of minutes per cubic foot. This is done by dividing the minutes per casting by the volume. Thus 0·3 cub. ft. takes 27·5 minutes to cast and the time per cubic foot is $\frac{27 \cdot 5}{0 \cdot 3} = 92$. The care that is required in correctly estimating labour costs between volumes of 0·3 and 2 cub. ft. can readily be seen from a study of *Fig.* 36.

Calculations for any Rate of Pay.

Table VIII is compiled so that for varying rates of pay the cost per cubic foot for different time rates can be seen at a glance. Caution must be exercised in making use of the tables of time rates when any complicated shapes are being priced. The best procedure is to use the tabulated figure as a basis, and add for extra labours, such as placing and drawing dowels for forming holes, or plugs for mortices. Sinkings or cavities may require the use of collapsible cores, in which case the time taken in stripping and assembly should be specially allowed for, or mouldings may be made up of many separate pieces all requiring separate handling. Sometimes castings are of a size altogether out of proportion to their volume, so that 2 or 3 men may be required to handle the heavy moulds, and the fixing of the reinforcement may take extra time because its light cross section allows it to twist and distort easily, so as to cause difficulty in ensuring the correct cover. Such contingencies should be looked for when estimating and suitable allowances made. Finishings are dealt with in Chapter X.

Labour Costs on Cast Stone.

Cast stone can be made by a semi-wet or a semi-dry process. The former is the cheaper, so far as labour charges are concerned, but a great deal more care is required in casting and stripping the moulds to ensure a perfect casting face and sharp arrises than is necessary with concrete products. As a rule, however, the semi-wet cast stone has a cement film over the face, which has to be removed. This can be done either by treating the face quickly with hydrochloric acid and immediately washing off with clean water, or by rubbing with a carborundum stone. To build up sharp arrises damaged by handling or stripping, it may be necessary to veneer the stone face, and rub off, a few days after casting, in which event the cost becomes comparable with semi-dry cast stone.

The semi-dry process is principally used to give a finished texture

TABLE VIII.

LABOUR COSTS OF MINUTES PER CUBIC FOOT FOR VARIOUS RATES OF PAY

Minutes	RATES							Minutes	RATES						
	1s.4d	1s.5d	1s.6d	1s.7d	1s.8d	1s.9d	1s.10d		1s.4d	1s.5d	1s.6d	1s.7d	1s.8d	1s.9d	1s.10d
	COST PER CUBIC FOOT								COST PER CUBIC FOOT						
									s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
14	3¾	4	4¼	4½	4¾	5	5¼	58	1/3½	1/4½	1/5½	1/6½	1/7¼	1/8½	1/9½
16	4¼	4½	4¾	5	5½	5¾	6	60	1/4	1/5	1/6	1/7	1/8	1/9	1/10
18	4¾	5	5½	5¾	6	6¼	6½	62	1/4½	1/5½	1/6½	1/7½	1/8½	1/9½	1/11
20	5½	5¾	6	6¼	6¾	7	7½	64	1/5	1/6	1/7	1/8	1/9½	1/10½	1/11½
22	6	6¼	6½	7	7½	7¾	8	66	1/5½	1/6¾	1/8	1/9	1/10	1/11	2/-
24	6½	6¾	7¼	7½	8	8½	8¾	68	1/6	1/7¼	1/8½	1/9½	1/10¾	2/0	2/1
26	7	7½	7¾	8¼	8¾	9	9½	70	1/6½	1/8	1/9	1/10	1/11½	2/0½	2/2
28	7½	8	8½	9	9½	10	10¼	72	1/7	1/8½	1/9½	1/11	2/-	2/1	2/2½
30	8	8½	9	9½	10	10½	11	74	1/8	1/9	1/10	1/11½	2/1	2/2	2/3
32	8½	9	9½	10	10¾	11	11¾	76	1/8½	1/9½	1/11	2/-	2/1½	2/2½	2/4
34	9	9½	10	10¾	11¼	1s. 0d.	1s. 0½d.	78	1/9	1/10	1/11½	2/1	2/2	2/3	2/4½
36	9½	10	10¾	11½	1s. 0d.	1s. 0½d.	1s. 1¼d.	80	1/9½	1/10¾	2/-	2/1½	2/2¾	2/4	2/5½
38	10	10¾	11½	1s. 0d.	1s. 0¾d.	1s. 1¼d.	1s. 2d.	82	1/10	1/11¼	2/0½	2/2	2/3½	2/4½	2/6
40	10½	11½	1s. 0d.	1s. 0¾d.	1s. 1½d.	1s. 2d.	1s. 2¾d.	84	1/10½	1/11¾	2/1	2/2½	2/4	2/5½	2/7
42	11	1s. 0d.	1s. 0½d.	1s. 1¼d.	1s. 2d.	1s. 2¾d.	1s. 3½d.	86	1/11	2/0½	2/2	2/3	2/5	2/6	2/7½
44	1s. 0d.	1s. 0½d.	1s. 1d.	1s. 2d.	1s. 2¾d.	1s. 3¼d.	1s. 4d.	88	1/11½	2/1	2/2½	2/4	2/5½	2/7	2/8
46	1s. 0½d.	1s. 1d.	1s. 2d.	1s. 2½d.	1s. 3¼d.	1s. 4d.	1s. 5d.	90	2/0	2/1½	2/3	2/4½	2/6	2/7½	2/9
48	1s. 1d.	1s. 1½d.	1s. 2½d.	1s. 3d.	1s. 4d.	1s. 5d.	1s. 5½d.	92	2/0½	2/2	2/3½	2/5	2/7	2/8	2/10
50	1s. 1½d.	1s. 2d.	1s. 3d.	1s. 4d.	1s. 4¾d.	1s. 5½d.	1s. 6½d.	94	2/1	2/2¾	2/4	2/6	2/7½	2/9	2/10½
52	1s. 2d.	1s. 2¾d.	1s. 3½d.	1s. 4½d.	1s. 5¼d.	1s. 6d.	1s. 7d.	96	2/1½	2/3¼	2/5	2/6½	2/8	2/9½	2/11
54	1s. 2½d.	1s. 3¼d.	1s. 4d.	1s. 5d.	1s. 6d.	1s. 7d.	1s. 8d.	98	2/2	2/3¾	2/5½	2/7	2/9	2/10	3/-
56	1s. 3d.	1s. 4d.	1s. 5d.	1s. 5¾d.	1s. 6¾d.	1s. 7½d.	1s. 8½d.	100	2/2½	2/4¼	2/6	2/7½	2/9½	2/11	3/1

to the stone, but as the mould has to be instantaneously stripped, damage may occur to arrises and moulded members and this needs immediate repair. The semi-dry stone is inverted on to a pallet before the mould is stripped, and the stone and pallet are carried to racks for drying. The stone when hard has to be rehandled to stacks to release

TABLE IX.—Average Times for Placing and Finishing Cast Stone.

UNIT VOLUME (cu. ft.)	MINUTES per cub. ft. from TABLE 7	Add for placing reinforcement cages 10%	SEMI-WET CAST STONE WITH RUBBED FINISH	SEMI-DRY CAST STONE WITH ACID FINISH
0·3	92	101	145	150
0·4	73	80	115	124
0·5	61	67	100	107
0·6	53	58	90	97
0·7	48	53	84	90
0·8	44	48	77	84
0·9	41	45	73	80
1·0	38	42	70	77
1·1	36	40	67	73
1·2	34	37	65	72
1·3	33	36	63	70
1·4	32	35	62	69
1·5	30	33	60	67
2·0	27	30	55	64
3·0	23	25	50	57
4·0	21	23	47	54
5·0	20	22	47	53
6·0	19	21	45	52
7·0	18	20	44	52
8·0	18	20	44	51

the pallet for further use. These processes, and the fact that the facing and concrete backing are tamped, make the semi-dry process more costly than semi-wet. It is seldom that a semi-dry stone can be given a rubbed finish as the face is usually very friable, but it benefits by treatment with hydrochloric acid. The particular benefits of casting semi-dry

stone are the economy that can be made in the cost of moulds and the fact that quick delivery can be given but, on a contract of considerable repetition work, it will be found that a number of moulds filled by the semi-wet process proves in the long run to be the cheaper method.

Crazing is not so visible on a semi-dry stone, but it blackens quickly on exposure in industrial towns, and is very porous, whereas a semi-wet cast stone is less porous and keeps cleaner and weathers in a similar way to natural stone.

Table IX gives the time rates of casting a semi-wet stone with a rubbed finish, and a semi-dry stone with an acid finish, but it should be borne in mind that indirect labour and mixing charges should be added as previously mentioned.

CHAPTER X

FINISHING COSTS OF CAST STONE AND SUNDRY ITEMS

TABLE IX includes for finishing a semi-wet cast stone with a rubbed texture, and for treating with acid a semi-dry cast stone.

A very wide range of surface finishes and treatment can be given and the time rates of the more frequently employed finishes are enumerated.

EXPOSED AGGREGATE.—This treatment consists of removing the cement film on the face of the stone so as to expose the colour and texture of the aggregate. The face is scrubbed with a stiff fibre or wire brush about 24 hours after casting, and is then thoroughly washed to remove all traces of cement. Allow 10 minutes per square foot.

ROUGH TROWELLING.—In small areas, 3 sq. ft. per minute.

HARD TROWELLING.—The surface is first roughly trowelled but the final process cannot be undertaken until the face has dried off, usually 2 to 4 hours after casting. Small areas, 5 minutes per square foot. Large areas, 3 minutes per square foot.

TROWELLING MOULDED NOSINGS.—To steps, 5 minutes per linear foot.

TOOLED FINISHES.—These are usually done by hand, and the extra cost should be added to each stone, according to the area treated, as the cost is considerable.

CHISEL DRESSING (8 to 12 bats to the inch).—Add to labour figures already given, 30 minutes per square foot.

DRAGGED FINISH.—This is usually done by dragging a metal comb over the surface, but if it is to be effective the stone should still be green, say 24 to 48 hours old according to the time of the year. Allow 5 minutes per square foot.

POLISHING.—To get a reasonably good polish at least three processes are necessary, with handling each time. The material to be polished is usually cast wet so that the casting cost should be based on wet-casting concrete products. Add to this, cost for polishing, 60 to 90 minutes per square foot according to the quality of finish required.

SUNDRIES.—Mortices for dowels, bolts, cramps, etc., 3*d*. each.

Cut hole in stone or concrete not exceeding 3 in. diameter, which could not otherwise be cast in, 6*d*. per inch of depth.

Ditto over 3 in. up to 6 in. diameter, 9*d*. per inch of depth.

Form holes up to 6 in. diameter at time of casting, 6*d*. each.

Stoolings or wall holds, if reasonable repetition required, and formed within the extreme section of the casting, 1*s*. each.

Fair ends, material only, up to 1 sq. ft., 6*d*. each; or calculate on actual material costs.

Mitres and angles. Price to nearest whole shilling at cost per linear foot of straight run of material on which the mitre is formed.

CHAPTER XI

EFFECT OF WEIGHT, REPETITION, REINFORCEMENT, AND MOULDS

SMALL units up to about 1 cub. ft. are handled by men, but over this volume it is desirable to handle by crane. The figures given in *Table* VII, with the addition of indirect charges, include all handling costs, but when a crane is installed it becomes an overhead expense. As in previous labour costs, the basic cost per cubic foot for handling is greater the less the volume.

When a considerable number of castings exactly the same is required, mass-production methods can be adopted, and these can reduce the labour costs enormously. Good organisation can also reduce labour costs by great amounts. Piece-work will usually be found to produce the greatest production but quality is likely to suffer, for which reason greater supervision may be necessary. The time rate of casting per cubic foot will never be much less than 15 m.p.c., but the unit time rate will be reduced from 23 minutes to about 15 minutes depending on the efficiency of the organisation. If machines are used for manufacture, a semi-dry mix has to be employed. Generally, for structural units, a wet or semi-wet mix is preferable. Closely-spaced bars in a reinforcement frame cause difficulty in surrounding the steel with concrete. Under such conditions castings should be vibrated.

Due to extra speed of casting by mass-production methods, wood moulds are liable to receive a fair amount of injury, calling for frequent repairs, and steel moulds are preferable if time allows for their manufacture. An additional advantage of using steel moulds is that they can be used in steam-curing chambers to obtain castings every 4 hours. This quick release of moulds reduces the mould costs considerably, and the appearance of a casting produced from a steel face is always better than that obtained from timber.

CHAPTER XII

EXAMPLES OF ESTIMATING LABOUR AND MATERIAL COSTS

EXAMPLE 22.—If no allowance is to be made for moulds, profit, or overheads, estimate the basic cost of labour and materials of tee beams as illustrated in the cross section, *Fig.* 37, if the beams are 12 ft. long. The concrete is to be composed of 3 parts $\frac{3}{8}$-in. shingle, $1\frac{1}{2}$ parts sand,

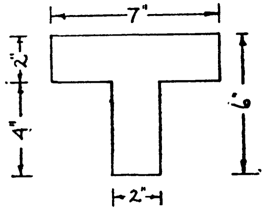


Fig. 37.

1 part Portland cement, measured by volume. The material costs are cement 50*s.* per ton, sand 13*s.* per cubic yard, and $\frac{3}{8}$-in. shingle 10*s.* per cubic yard. The rates of pay are 1*s.* 6*d.* per hour.

Solution.—The cross-sectional area of the beam is

$$7 \text{ in.} \times 2 \text{ in.} + 4 \text{ in.} \times 2 \text{ in.} = 22 \text{ sq. in.}$$

Its volume is $\frac{22}{144}$ sq. ft. $\times$ 12 = 1·84 cub. ft.

From *Table* II the quantities of materials are

		£	s.	d.
Cement	640 lb. at 50*s.* per ton =	0	14	3
Sand	0·39 cub. yd. at 13*s.* per cubic yard =	0	5	1
$\frac{3}{8}$-in. Shingle	0·78 ,, ,, at 10*s.* ,, ,, ,, =	0	7	10
		1	7	2
	Add 5 per cent. for waste	0	1	4
		1	8	6

$$\text{Price per cubic foot} = \frac{28s.\ 6d.}{27} = 1s.\ 0{\cdot}7d., \text{ say, } 1s.\ 1d.$$

From *Table* VII the time rate for making a casting of 2 cub. ft. volume is 27 m.p.c. Add for mixing 2 m.p.c. = 29 m.p.c. From *Table* VIII the price at 1*s*. 6*d*. per hour for a casting taking 29 m.p.c. is 9*d*. per cubic foot.

The basic price is made up as follows:

Materials	1*s*. 1*d*. per cubic foot
Labour, 29 m.p.c. at 1*s*. 6*d*.	9*d*. ,, ,, ,,
Add for indirect charges, 43 per cent. of direct labour	4*d*. ,, ,, ,,
	2*s*. 2*d*. per cubic foot

Example 23.—Estimate the basic cost of a 12 in. × 3 in. × 3 ft. long coping, to be cast in Portland stone finish with 1 in. thick facing, if the material costs are as shown in *Table* V. The coping is to be cast semi-wet and to be veneered and rubbed off. The rate of pay is to be taken at 1*s*. 7*d*. per hour. No mould, overhead, or profit charges are to be added.

Solution.—The volume of a coping is 0·25 × 3 = 0·75 cub. ft. From *Table* VI, the material costs with three fair faces is (for 0·7 cub. ft.)

		2*s*. 6½*d*. per cubic foot
From *Table* IX, for a volume of 0·7 cub. ft. the casting time is .	84 m.p.c.	
Add for mixing . . .	2 ,,	
	86 ,,	
86 m.p.c. at 1*s*. 7*d*. per hour (from *Table* VIII) is		2*s*. 3*d*. ,, ,, ,,
Add 43 per cent. indirect charges . .		11½*d*. ,, ,, ,,
		5*s*. 9*d*. per cubic foot.

Example 24.—A terrazzo slab 3 ft. × 2 ft. × 3 in. thick is to have a facing 1 in. thick, and is to be polished. If no mould, overhead, or profit charges are to be added, what is the cost of the slab?

The terrazzo facing is to be composed of 2 parts ¼-in. marble chips, 1 part ⅛-in. chips, and 1 part of white cement coloured with 5 per cent. of green pigment. The backing is to be 3 : 1½ : 1 as in Example 22. The material costs are: Marble chips, 70*s*. per ton; cement, £10 5*s*. per ton; green pigment, 9*d*. per lb.; wages, 1*s*. 9*d*. per hour.

Solution.—

Volume of facing, $3 \times 2 \times \frac{1}{12}$	$= 0{\cdot}5$ cub. ft.	
Volume of backing, $3 \times 2 \times \frac{2}{12}$	$= 1{\cdot}0$,, ,,	
Total volume	$1{\cdot}5$,, ,,	
Polished surface $= 3 \times 2$	$= 6{\cdot}0$ sq. ft.	

The specific gravity of marble is about 2·65 and therefore *Table* II can be used. The cost of the facing is

	£	s.	d.
870 lb. cement at £10 5*s*. per ton, say,	4	0	0
0·35 × 27 × 100 = 945 lb. ⅛-in. chips			
0·74 × 27 × 100 = 1998 lb. ¼-in. chips			
2943 lb. at £3 10*s*. per ton, say,	4	12	0
5 per cent. of 870 = 43½ lb. pigment at 9*d*. lb.	1	12	8
	10	4	8
Add 5 per cent. waste	0	10	3
	10	14	11

Price per cubic foot of facing $= \dfrac{£10\ 14s.\ 11d.}{27} =$ say 8*s*. 0*d*.

,, ,, ,, ,, ,, backing as Example 22 is 1*s*. 1*d*.

Estimate of Cost.—

		s	d.
Materials—Facing, 0·5 cub. ft. at 8*s*. per cub. ft.	=	4	0
Backing, 1 cub. ft. at 1*s*. 1*d*. per cub. ft.	=	1	1
Labour—From *Table* VII, casting time 30 m.p.c.			
Add mixing 2 ,,			
32 ,,			
From *Table* VIII, cost per cubic foot = 11*d*.			
Cost per slab = 1½ × 11*d*.	=	1	4½
Add for indirect charges, 43 per cent.	=	0	7
Add for polishing (see Chapter X) 90 minutes per square foot			
$6 \times 90 = \frac{540}{60} = 9$ hours at 1*s*. 9*d*.		15	9
		22	9½

It must be noted that no mould, overhead, or profit charges are included, and that all material charges are hypothetical.

CHAPTER XIII

COST OF MOULDS

THE probable cost of moulds is one of the biggest problems in estimating the cost of concrete products and cast stone. If only a few castings are required from a mould, the estimate of the cost of moulds should be a generous one, but as a rule there is considerable repetition, or moulds can be quickly altered to make different lengths by having a moving end. If there is considerable repetition the unit cost of moulds is small, so that an error in estimating the cost, especially if on the high side, is not a serious matter.

Unit measurement of moulds is most conveniently based on the surface area of the casting actually in contact with the mould, and is hereafter described as the "contact area." Reliable costing data can be accumulated on the basis of contact area and the smaller the volume of a unit the greater the basic cost.

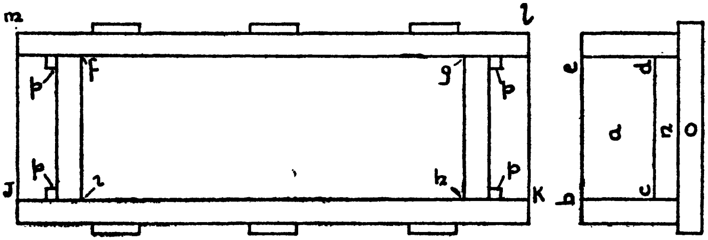


Fig. 38.

The cost of timber for moulds is also based on contact area, but a percentage must always be added for the extra timber required for the projections at the ends of the bottom and sides, battens, etc.

In *Fig.* 38 the contact area of the casting (*a*) is made up of the sum of the surfaces in contact with the mould, which is $bc + cd + de$ multiplied by the length *fg*, plus two ends each of area $bc \times cd$. The extra timber for which to allow comprises the projections *ij*, *hk*, *lg*, *fm*, and the extra depth on each side represented by the thickness of the bottom *n*. In addition, the battens *o* and the spacers *p* must be added. The quantity of timber can be exactly calculated, but it is convenient to know that in the case of small moulds 100 per cent. increase, and for large moulds 50 per cent. increase, should be allowed on the contact area

in estimating the cost of timber; this figure also allows for waste. An all-in average of 75 per cent. increase is a convenient figure to use.

Timber is most commonly used for mould making, although plaster, gelatine, concrete, and steel moulds are also used, each having particular advantages for certain types of castings.

Plaster and Concrete Moulds.

Plaster deteriorates rapidly when used for moulds for the manufacture of wet castings, and is really only satisfactory when one or two castings are required. It is conveniently used for balusters, column capitals, etc., but if time permits it is more satisfactory to use concrete moulds. Plaster moulds can be made by a specialist firm, from whom prices can be obtained. The cost of concrete moulds can be estimated in a similar way to ordinary castings, adding for the richer concrete necessary and additional finishing.

Gelatine Moulds.

Gelatine is used for moulds when the casting face is intricate with undercut faces, such as a coats-of-arms, scrolls, Corinthian column capitals, and sculpture. As a rule, however, a model exists to be copied, so that the mould costs consist of covering the model with clay, and making a shell around the clay with plaster which can be removed in pieces when hard. The clay is removed from the model, the shell re-assembled around or over the model, and gelatine is poured to fill the cavity between the model and the shell. These costs seldom exceed the cost of a timber mould for castings of equal volume, and as the gelatine can be used again very many times with the addition of a small proportion of fresh gelatine, it is not necessary to make special calculations, the cost being conveniently taken as for the timber moulds, given later on. If the model is to be made it is best undertaken by carvers, from whom a price can be obtained. It is usually executed in plaster.

Steel Moulds.

The cost of steel moulds is also obtained from firms who specialise in their manufacture. The great advantage of steel moulds is the number of times they can be used without damage. A timber mould will produce up to about 50 castings, but the damage due to moisture and caused by cleaning and tamping, etc., usually calls for constant overhauling. Steel moulds can produce hundreds of castings, the casting face is excellent, and they lend themselves admirably to steam curing, thereby economising in the number of moulds required for a given production.

Timber Costs.

Average contact areas can be worked out, and the result of these calculations is given in *Table* X. The value of the timber in a mould is found by increasing the contact area by 75 per cent. and calculating the cost at the current price of timber. The price of timber is quoted at per standard of 165 cub. ft. The cost of timber can either be reduced to a price per cubic foot or a price per square foot of various thicknesses. Practice has shown that 2-in. timber resists warping and twisting very much better than thinner boards, even though the latter may be strongly battened.

In *Table* X all timber is assumed to be 2 in. thick, and the cost is

TABLE X.—Assumed Contact Areas for Unit Volumes and Cost of Timber for Moulds.

Unit Volume Cub. Ft.	Area (Sq. ft.)				Incidentals for Bolts Nuts, Screws etc. + 10%	Timber Cost @ £50 Std = 1s. sq. ft. 2" thick
	Two Sides and Bottom	Two Ends	Total	+ 75%		
0·3	2·3	0·2	2·5	4·6		4s.7d.
0·4	2·9	0·28	3·18	5·9		5s.11d.
0·5	3·75	0·35	4·10	7·6		7s.7d.
0·6	4·0	0·42	4·42	8·2		8s.3d.
0·7	4·25	0·5	4·75	8·8		8s.10d.
0·8	4·5	0·55	5·05	9·3		9s.4d.
0·9	4·6	0·6	5·2	9·6		9s.7d.
1·0	5·0	0·66	5·66	10·4		10s.5d.
1·1	5·1	0·73	5·83	10·8		10s.10d.
1·2	5·4	0·8	6·2	11·4		11s.5d.
1·3	5·6	0·87	6·47	12·0		12s.0d.
1·4	5·8	0·9	6·7	12·4		12s.5d.
1·5	6·1	1·0	7·1	13·1		13s.1d.
2·0	7·5	1·4	8·9	16·5		16s.6d.
3·0	9·0	2·0	11·0	20·4		20s.5d.
4·0	12·0	2·7	14·7	27·2		27s.2d.
5·0	13·0	3·3	16·3	30·2		30s.2d.
6·0	15·0	4·0	19·0	35·0		35s.0d.
7·0	17·0	4·7	21·7	40·0		40s.0d.
8·0	18·5	5·2	23·7	44·0		44s.0d.

based on £50 per standard. The figures in *Table* X represent good averages, but there is, of course, a small difference in area for various sections and lengths for a specified volume, and when an estimate is of considerable magnitude or the product is of an unusual shape it is as well to deal with it separately. The purpose of the table is to enable the information to be embodied in the final estimating chart, so that fairly accurate and rapid estimating can be carried out. If the cost of timber varies it would be necessary to recalculate *Table* X, but the variation would be directly proportional to the cost per standard.

One great advantage of timber for moulds is the fact that when the mould is finished with the timber can often be re-used. It is a good idea to dismantle moulds and to stack sides and bottoms in various widths. It is important, however, that every special job should completely cover the cost of its own moulds, and it is not wise to credit any allowance for salvage value.

Incidental Materials.

It is much too laborious a task to compute accurately in detail such items as bolts, screws, nails, dogs, etc., at the time of estimating, and generally an addition of 10 per cent. to the timber cost will cover all such items. *Table* X includes these items.

Labour Charges of making Timber Moulds.

To arrive at a very accurate estimate of the cost of a wood mould it is necessary to calculate the exact quantity of timber to be used, and also to assess the superficial area of the whole of the timber to be worked in order to calculate the labour charges. The cost of the mould would then be made up of the sum of the following items: Materials; Direct charges based on worked area; Indirect charges; and Incidentals.

The unit price per square foot to use for estimating labour costs varies according to the amount of machine work that can be used in the preparation of the boards, or alternatively to the amount of bench work that is necessary, and of course to the area of timber in the mould. Well-equipped joinery manufacturers are able to prepare timber for repetition work very much cheaper than most mould shops of products manufacturers because, owing to the great variation in the size and shape of moulds for concrete products, machines such as four-cutters and five-cutters are not economical to install as they can seldom be fully used. To make a separate estimate of mould costs for each item as just described is, of course, out of the question, when perhaps dozens of estimates each containing numerous items are to be prepared in a

day. It is necessary therefore to use a rapid method with a reasonable degree of accuracy.

The cost of manufacture of wood moulds is most conveniently calculated on time rates based on the surface contact area of the casting. For small moulds the manufacturing time will be about 2 hours per square foot, but the larger the mould becomes the less becomes the time rate per square foot of contact area, until the time rate approaches that required for the manufacture of new shuttering for small mass concrete work, which is about 30 minutes per square foot. A complication arises, however, on arriving at a suitable method of measurement to assess the effect on cost of mouldings, accurate positioning of jigs, circular work, etc. The only reliable guide is actual experience but, as previously pointed out, provided the repetition from a mould is considerable, the unit mould cost is small, so that by adding 50 per cent. to the mould charges an estimator will know that his price is on the right side without unduly inflating the basic price of the final estimate of cost.

Variations of Unit Cost.

The maximum unit time to manufacture small moulds is 2 hours (120 minutes) per square foot, and the time rate is reduced as the mould area increases. In a similar way to the method of calculating time rate variations of casting labours, mould time rate variations can be calculated. If the smallest mould is assumed to have a contact area of about 3 sq. ft., the time rate for its manufacture is 120 minutes per square foot, or 360 minutes for the mould. If a basis of 30 minutes per square foot for large work is used for a mould of 3 sq. ft. the time is 90 minutes, which leaves a time rate per mould of $360 - 90 = 270$ minutes. If figures are calculated on the basis of 270 minutes per mould and 30 minutes per square foot of contact area, their sum is the time for making a plain mould, and if this figure be divided by the area, the results will be fairly reliable unit rates, and agree very favourably with actual times.

Table XI has been worked out to show the effect of the time rate variation, and *Fig.* 39 is useful for ascertaining intermediate values; it is of interest to note that it follows the characteristic curve of pre-cast concrete labour charges.

Effect on Cost of Alterations to Moulds.

In many factories simple mould alterations, such as altering moving ends, are carried out by the concrete casters at the making benches, but in large factories it is more necessary to work to a definite system and a foreman mould-maker should be entirely responsible for the

TABLE XI.

TIME-RATE VARIATION OF PLAIN TIMBER MOULDS																	ADDITIONS
AREA (sq. ft)	3	4	5	6	7	8	9	10	11	12	13	14	15	20	25	30	CIRCULAR AND MOULDED WORK + 50%
CONSTANT	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	—
TIME @ 30 mins. sq. ft.	90	120	150	180	210	240	270	300	330	360	390	420	450	600	750	900	INDIRECT CHARGES
TOTAL	360	390	420	450	480	510	540	570	600	630	660	690	720	870	1020	1170	+ 33⅓%
AVERAGE TIME PER SQUARE FOOT	120	98	84	75	69	64	60	57	55	53	51	50	48	44	41	39	

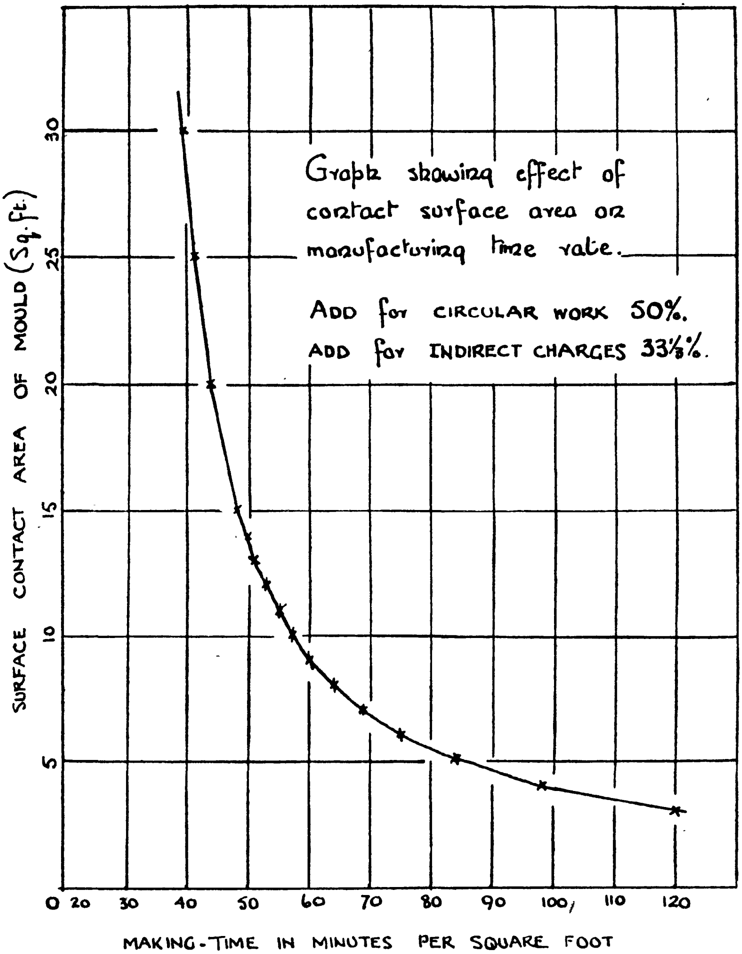


Fig. 39.

accuracy of all moulds. It then becomes necessary to return all moulds to the mould shop when alterations are needed, to enable the foreman or checker to pass all moulds out to the casting shop. If this system is adopted some moulds must be handled many times, but it ensures accuracy and pays in the long run.

MOVING ENDS.—The cost of altering the length of a mould by adjustment of a moving end probably takes no longer than 30 minutes, but

more often than not the mould has already produced the number of castings expected from it, so that when the alteration has been made it is equivalent to a new mould at the cost of an alteration. If it can be ascertained in advance that there will be plenty of repetition, the cost of adjustment of moving ends can safely be ignored.

MITRES AND RETURN ENDS.—The usual practice is to price a mitre or a return end at the nearest round figure in shillings to the price per linear foot of the item to which it refers. Thus if a cornice is estimated to cost 7*s.* 9*d.* per linear foot the cost of a mitre or return end would be 8*s.* This charge is largely to cover the cost of alterations to the mould, but in the case of cast stone a small part of it is required to cover the cost of extra facing material. The actual time required to form a mitred return end in an elaborate mould can be considerable, but as a rule a certain amount of repetition is expected. Two things, however, should be borne in mind. First, if there is no repetition the method of pricing as outlined will not adequately cover the cost of a mitre, and the price should be suitably increased. Secondly, if there is very considerable repetition, this charge can be reduced at the discretion of the estimator.

ALTERATION OF A SECTION.—Such an alteration should be considered as a new mould and priced accordingly.

INDIRECT CHARGES.—Certain operations in a mould shop cannot always be directly allocated to the cost of a mould. Such items are machinists' time, the time taken in recovering timber, labourers' time in carrying moulds, and cleaning up the shop. These indirect operations represent an increase of about 33⅓ per cent. on the actual time of making a mould.

Output from a Mould.

Before a basic price for mould charges can be fixed, the amount of repetition must be closely estimated. If this is not possible, the best procedure is to assume a given output from a mould and specify it in the quotation.

Obviously the greater the output from a mould the less the basic mould cost. For instance, if a mould costing 40*s.* produces 40 cub. ft., the basic cost would be 1*s.* per cubic foot. If the production were 80 cub. ft., the basic cost would be 6*d.* per cubic foot. The limiting factor of output is delivery time. On ordinary building work prompt delivery is of the utmost importance, so that it would be very unwise to assume greater production than could be got in a reasonable period for delivery. As a rule four weeks is as long as a customer is prepared to wait for materials for a small job. Generally, the smaller the job

the quicker the material is required. Of course, this is really not long enough to ensure proper curing and hardening of the concrete castings, because in this period of time the mould has to be made and castings made and cured. If four weeks are allowed for delivery, and ten days of this period are allowed for maturing the last casting, and two days for the setting out and manufacture of a mould, the time left for manufacture is 4 weeks of $5\frac{1}{2}$ days less 12 = 10 days. On large contracts longer periods for delivery can be expected, and in close estimating it is imperative to have some idea about the delivery programme.

Number of Moulds to Manufacture.

Having arrived at the actual number of casting days available, the problem is to find how many moulds will be required.

If the castings are to be wet cast, it is usual to leave them in the mould for 24 hours before stripping the mould for re-use. In this case the number of moulds required would be the total number of identical castings divided by the number of casting days. For instance, if 48 similar lengths of coping are required for delivery in 4 weeks, and 10 casting days are available for production, the number of moulds required would be 48 divided by 10, say, 5. Three of these moulds would each produce 10 castings and two of them would only produce 9.

The question now arises whether the production from a mould can be increased. If the products are to be wet cast, moulds can, except in very cold weather, be stripped twice a day by adding about $1\frac{1}{2}$ lb. of calcium chloride to 112 lb. of cement, reducing the water content, and vibrating. By steam curing moulds can be re-used two or three times a day, but timber moulds will quickly twist, for which reason the material does not particularly lend itself to this treatment. Steel moulds, on the other hand, can be used every 2 to 4 hours if the castings in them are steamed, and very good castings result if the temperature in the steam chamber or kiln does not exceed 120 deg. F.

Semi-dry casting makes the greatest economy in moulds, and very much quicker delivery can be given when this method is adopted. There are very decided disadvantages in semi-dry casting, however, which are enumerated as follows:

(1) The compressive strength of the material is low.

(2) The material is porous.

(3) The material, being porous, allows dirt to be washed into the voids, which results in blackening of the face.

(4) The material is easily damaged in handling and transport.

The appearance of a new semi-dry casting, however, is excellent, and a really skilled operator can to a great extent overcome the objec-

tions mentioned if very great care is taken in adding as much water as possible to the mix consistent with it being worked semi-dry.

On large-scale repetition work it will usually be more expensive to make semi-dry castings than it is to make a number of moulds, and wet cast, or vibrate with high water-cement ratio mixes, because the extra labour entailed in casting semi-dry will quickly offset any saving in moulds.

CHAPTER XIV

COMBINED TIMBER AND LABOUR CHARGES FOR MOULDS AND EXAMPLES OF ESTIMATES

AFTER the calculation of estimated costs of timber, incidentals, labour, and indirect charges has been completed, it is convenient to tabulate the results, because for normal work they make a very reliable and quick method of arriving at a basic cost. The method of arriving at estimated mould costs so far described gives the cost of a mould, so that for rapid estimating these figures have to be reduced to terms of cubic feet. Obviously it is necessary to decide on the anticipated output that can be obtained, which, as previously stated, is dependent on delivery and demand. This mould output, multiplied by the volume of the casting it produces, gives the total production that the mould can be expected to produce. It may be that, once a mould is made, further production from it can be foreseen, in which case a purely hypothetical production has to be assessed. The life of a timber mould must, of course, be considered when assessing such a figure. With care a mould might make hundreds of castings, but if a wet process is being used it will probably expand and twist, and will then require repeated overhauling for which some allowance should be made. The best procedure, however, is to assume a maximum production of 50 castings from any mould which is certain to be used repeatedly, and if there is any doubt to assume about 25 uses.

When large quantities of castings are produced from a mould the basic cost becomes quite low, and conversely, if only a few castings are required, the basic cost can be considerable. *Table* XII shows the very great range of basic prices.

There are cases when, if only one or two cast stone castings are to be made from a mould, natural stone may be cheaper. In such cases it may be preferable to cast blocks and for masons to work them out of the solid. For example, if a mould for a casting of 0·5 cub. ft. volume has to produce only two castings, the cost of the mould would be

Timber (from *Table* X)	7*s*. 7*d*.
Labour (,, ,, XII)	13*s*. 3*d*.
Indirect charges (+ 33⅓ per cent.)	4*s*. 5*d*.
	25*s*. 3*d*.

The basic cost would therefore be 25*s*. 3*d*. per cubic foot.

If 50 castings are to be made from this mould, the volume would be $50 \times 0{\cdot}5 = 25$ cub. ft., and the basic cost would be

$$\frac{25s.\ 3d.}{25} = 1s. \text{ per cubic foot approximately.}$$

This example illustrates how important it is to pre-determine the production of any one mould. Such calculations at the time of pricing a bill of quantities become laborious, and often an estimator will make a good guess at what is thought to be a competitive price. It is seldom that each separate mould is costed for a contract, and therefore it never becomes known how accurate the "good guess" may have been. A table giving the cost of a mould based on the manufacturer's actual timber and labour charges can show the reduction of mould charges for quantity, so that the basic cost for any output can be seen at a glance.

Table XII is compiled from the data given in *Tables* X and XI. The joiners', or mould-makers', rate has been taken at 2*s*. an hour.

Table XI was computed for various areas in whole numbers, and in order that this may be correlated to the previous tables given in volume it is necessary to refer to *Fig.* 39 so that the intermediate values of approximate areas calculated for the various volumes in *Table* X can be ascertained.

The calculations of basic cost in *Table* XII are computed to the next highest penny. They only represent a close approximation of the probable cost, because there are so many cases where castings of the same volume have different areas and shapes. The Standard Method of Measurement recommends the measurement of cast stone as the smallest rectangular block out of which it could be obtained if it were natural stone, and if this practice is adopted it will usually be found that the basic mould costs given in *Table* XII are adequate.

In the case of cornices, architraves, stringcourses, etc., extra timber and labour are used in the moulds to pack them up and form the mouldings. As has previously been recommended, 50 per cent. should be added for extra labour, but the extra timber is not allowed for in *Table* XII. On the other hand there is a considerable saving in concrete materials by the reduction of net volume by the moulded and undercut surfaces, and this economy usually adequately covers the extra timber costs.

When an estimate for moulds is required for products which have shapes which cannot be embraced by the sections given in *Table* V, an estimate of cost should be computed in detail, based on time rate of contact area as given in *Table* XI. Caution must be exercised, however,

TABLE XII

BASIC MOULD COSTS

UNIT VOLUME Cub. Ft.	AVERAGE CONTACT AREA Sq. Ft.	TIMBER, WASTE AND INCIDENTAL COSTS FROM TABLE X	LABOUR COSTS AT 2s 0d. HOUR BASED ON TIME FROM TABLE XI	INDIRECT LABOUR CHARGES + 1/3	TOTAL	BASIC COST PER CUBIC FOOT FOR VARIOUS OUTPUTS — ADD FOR MOULDED CIRCULAR AND SPECIAL SHAPES 50%																
						1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	50
		s. d.	s. d.	s. d.	s. d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.	s.d.
0·3	2·5	4·7	11·3	3·9	19·7	65/3	32/7	21/9	16/4	13/0	10/10	9/4	8/2	7/3	6/6	4/4	3/3	2/7	2/2	1/10	1/8	1/4
0·4	3·18	5·11	12·5	4·2	22·6	56/3	28/1	18/9	14/0	11/3	9/4	8/0	7/0	6/3	5/8	3/9	2/10	2/3	1/11	1/8	1/5	1/2
0·5	4·10	7·7	13·3	4·5	25·3	50/6	25/3	16/10	12/8	10/0	8/5	7/3	6/4	5/7	5/1	3/5	2/6	2/0	1/8	1/5	1/3	1/0
0·6	4·42	8·3	13·6	4·6	26·3	43/9	21/11	14/7	10/11	8/9	7/3	6/3	5/6	4/10	4/4	2/11	2/2	1/9	1/6	1/3	1/1	0.11
0·7	4·75	8·10	13·10	4·7	27·3	39/0	19/6	13/0	9/9	7/10	6/6	5/7	4/10	4/4	3/11	2/7	1/11	1/7	1/4	1/2	1/0	0.10
0·8	5·05	9·4	14·0	4·8	28·0	35/0	17/6	11/8	8/9	7/0	5/10	5/0	4/4	5/11	3/6	2/4	1/9	1/5	1/2	1/0	0.11	0.9
0·9	5·2	9·7	14·3	4·9	28·7	31/10	15/10	10/7	7/11	6/4	5/4	4/7	4/-	3/6	3/2	2/2	1/7	1/4	1/1	0.11	0.10	0.8
1·0	5·66	10·5	14·9	4·11	30·1	30/1	15/1	10/0	7/6	6/0	5/0	4/4	3/9	3/4	3/0	2/0	1/6	1/3	1/0	0.11	0.9	0.7
1·1	5·83	10·10	14·10	4·11	30·7	27/9	14/6	9/3	7/0	5/7	4/8	4/0	3/6	3/1	2/9	1/10	1/5	1/2	0.11	0.10	0.9	0.7
1·2	6·2	11·5	15·3	5·1	31·9	26/6	13/3	8/10	6/7	5/4	4/5	3/10	3/4	2/11	2/8	1/9	1/4	1/1	0.11	0.9	0.8	0.7
1·3	6·47	12·0	15·6	5·2	32·8	25/1	12/7	8/5	6/3	5/0	4/2	3/7	3/2	2/10	2/6	1/8	1/3	1/0	0.10	0.9	0.8	0.6
1·4	6·7	12·5	15·9	5·3	33·5	23/10	12/0	8/0	6/0	4/9	4/0	3/5	3/0	2/8	2/5	1/7	1/3	1/0	0.10	0.9	0.8	0.6
1·5	7·1	13·1	16·0	5·4	34·5	23/0	11/6	7/8	5/9	4/7	3/10	3/4	2/11	2/7	2/4	1/7	1/2	0.11	0.9	0.8	0.7	0.6
2·0	8·9	16·6	18·0	6·0	40·6	20/3	10/2	6/9	5/1	4/1	3/5	2/11	2/7	2/3	2/1	1/4	1/0	0.10	0.8	0.7	0.6	0.5
3·0	11·0	20·5	20·2	6·9	47·4	15/9	7/11	5/3	4/0	3/2	2/8	2/3	2/0	1/9	1/7	1/1	0.10	0.8	0.7	0.6	0.5	0.4
4·0	14·7	27·2	24·0	8·0	59·2	14/9	7/5	4/11	3/9	3/0	2/6	2/2	1/10	1/8	1/6	1/0	0.9	0.7	0.6	0.5	0.5	0.4
5·0	16·3	30·2	25·6	8·6	64·2	12/10	6/5	4/3	3/3	2/7	2/2	1/10	1/8	1/5	1/4	0.11	0.8	0.6	0.5	0.5	0.4	0.3
6·0	19·0	35·0	28·6	9·6	73·0	12/2	6/1	4/1	3/1	2/6	2/1	1/9	1/7	1/5	1/3	0.10	0.8	0.6	0.5	0.5	0.4	0.3
7·0	21·7	40·0	31·4	10·5	81·9	11/8	5/10	3/11	2/11	2/4	2/0	1/8	1/6	1/4	1/2	0.10	0.7	0.6	0.5	0.4	0.4	0.3
8·0	23·7	44·0	32·7	10·10	87·5	10/11	5/6	3/8	2/9	2/2	1/10	1/7	1/5	1/3	1/1	0.9	0.7	0.6	0.5	0.4	0.4	0.3

when dealing with anything unusual because *Table* XII is only prepared for simple products.

Examples of Estimating Mould Costs.

TWENTY-FIVE CASTINGS.

EXAMPLE 25.—What is the basic cost of a timber mould for a coping 12 in. × 3 in. × 3 ft. long? Twenty-five castings can be produced from each mould to give delivery in the time specified.

Solution.—The volume of the coping is $\frac{36}{144} \times 3 = 0{\cdot}75$ cub. ft. Referring to *Table* XII, the next lowest cube tabulated to this is 0·7, and the basic cost shown for an output of 25 is 1*s.* 7*d.* per cubic foot.

FOUR CASTINGS.

EXAMPLE 26.—If only four castings are to be made of the foundation block shown in *Fig.* 30, estimate the basic mould cost.

Solution.—*Table* XII was compiled for sections of approximately 3-ft. lengths, so that it would be unreliable to use the table for estimating the cost of this mould. It must be calculated in detail.

The contact area is

$$4(1 \text{ ft. } 11 \text{ in.} \times 11 \text{ in.}) + 4(1 \text{ ft. } 5\tfrac{1}{2} \text{ in.} \times 7{\cdot}4 \text{ in.}) + (1 \text{ ft.} \times 1 \text{ ft.})$$
$$= 7{\cdot}04 + 3{\cdot}6 + 1 = 11{\cdot}64 \text{ sq. ft.}$$

The cost is made up as follows:

Timber. 11·64 sq. ft. + 75 per cent. = 20·37 sq. ft.

	£	s.	d.
Using 2-in. timber at £50 per standard = 1*s.* per square foot, the cost is 20·37 at 1*s.*	= 1	0	5
Incidentals (add 10 per cent.), say,	= 0	2	0
Labour for a mould of 12 sq. ft. is 53 minutes per square foot at 2*s.* per hour	= 1	1	2
Indirect charges (add 33⅓ per cent.)	= 0	7	1
As there is more labour entailed in forming the splayed top, and only four casts are required, it is as well to consider the mould as "moulded" and add 50 per cent.	= 0	14	1
Total . .	3	4	9

The volume of the base is 4·3 cub. ft. and the basic cost is

$$\frac{£3\ 4s.\ 9d.}{4 \times 4{\cdot}3} = 3s.\ 9d. \text{ per cubic foot.}$$

As a matter of interest, *Table* XII for a plain mould gives the basic

cost as 3*s*. 9*d*. per cubic foot, which would be on the side of safety if 50 per cent. for moulded work were added.

TWO HUNDRED CASTINGS.

EXAMPLE 27.—If 600 linear feet of saddle-back coping as in *Fig.* 31 are to be manufactured for delivery in 8 weeks, what is the basic mould cost? The coping is to be cast in 3-ft. lengths.

Solution.—The number of castings is $\frac{600}{3} = 200$. Allowing 5 days for making the moulds, and 10 days for the maturing of the last castings, the number of making days will be $8 \times 5\frac{1}{2} = 44 - 15 = 29$ days. This means that each mould can be used 29 times, and $\frac{200}{29} = 6{\cdot}9$, say, 7 moulds will be required.

The overall volume of the coping is

$$\frac{13 \text{ in.} \times 6 \text{ in.}}{144} \times 3 \text{ ft.} = 1{\cdot}63 \text{ cub. ft.}$$

From *Table* XII the basic cost of a volume of 1·5 cub. ft. (the next lowest figure) for an output of 30 castings is 9*d*. per cubic foot. It is justifiable to take the higher output in view of the use of a smaller volume. This figure can be calculated more accurately thus: Total volume $= 29 \times 1{\cdot}63 = 47{\cdot}3$ cub. ft. The total cost of the mould is shown as 34*s*. 5*d*. and the basic cost is $\frac{34s.\ 5d.}{47{\cdot}3} = 8\frac{3}{4}d.$ per cubic foot.

HEAVY MOULD.

EXAMPLE 28.—Estimate the cost of a timber mould for the manufacture of lighting pylons as illustrated in *Fig.* 33.

Solution.—The mould is of considerable length, and therefore the sides will be heavy and allowance must be made for the extra labour required to handle the timber and mould. The best procedure is to add 50 per cent. for the extra time. The contact area is

$$3\left(20 \text{ ft.} \times \frac{5 \text{ in.} + 10 \text{ in.}}{2}\right) + \frac{5 \text{ in.} \times 5 \text{ in.}}{144} + \frac{10 \text{ in.} \times 10 \text{ in.}}{144}$$

$$= 37{\cdot}5 + 0{\cdot}174 + 0{\cdot}695 = 38{\cdot}369, \text{ say, } 38{\cdot}4 \text{ sq. ft.}$$

The dimension of 20 ft. is not strictly correct, but the error is so small that it can be ignored.

Timber.—38·4 sq. ft. + 75 per cent. = 67·2 sq. ft. If the timber

costs £50 a standard and $2\frac{1}{2}$-in. timber is to be used, the price per square foot is 1*s*. 3*d*., and the total cost is

		£	*s*.	*d*.
67·2 × 1*s*. 3*d*., say		4	4	0
Incidentals.—(Add 10 per cent.), say		0	8	5
Labour.—Constant	= 270 minutes			
38·4 sq. ft. at 30 minutes	= 1152 ,,			
	1422 ,,			
$\frac{1422}{60}$ = 23·7, say, 24 hours at 2*s*.	=	2	8	0
Indirect costs (add $33\frac{1}{3}$ per cent.)		0	16	0
Add for additional labour in handling heavy parts (50 per cent.)		1	12	0
Total		9	8	5

CHAPTER XV

REINFORCEMENT

MILD steel is rolled for reinforcement in diameters varying from $\frac{1}{8}$ in. upwards and has an ultimate tensile strength of 28 to 32 tons per square inch. Steel reinforcement should be specified to comply with the current British Standard Specification.

Diameters from $\frac{3}{16}$ in. up to $\frac{3}{4}$ in. are usually employed in pre-cast concrete products; $\frac{1}{8}$-in. diameter wires are sometimes used for links. Smaller diameters are generally preferable because they have a greater surface area than large diameter bars for a given sectional area of steel, and the total bond strength thus becomes greater. For example, two $\frac{1}{2}$-in. diameter bars have an area of 0·392 sq. in. and a perimeter of 3·142 in. Three $\frac{3}{8}$-in. diameter bars have an area of 0·330 sq. in.; this area is less than two $\frac{1}{2}$-in. bars, but their perimeter is greater, being 3·534 in. Five bars $\frac{5}{16}$ in. in diameter have an area of 0·383 sq. in., which again is less than the area of two $\frac{1}{2}$-in. bars, but in this case the perimeter is 4·910 in.

Quantities of Steel.

When the quantities of reinforcement are specified it is a simple matter to arrive at the weight of steel by reference to tables of weight, but if the ends of the bars are to be hooked care must be taken to add the appropriate extra length of steel. *Table* XIII gives the area and weight of varying diameters of reinforcing bars. *Table* XIV gives the additional length to add to bars for one and two hooked ends.

It is advisable to keep the weights of bars of different diameter under $\frac{5}{8}$ in. separately, because the price of steel reinforcement increases with reduction of diameter.

EXAMPLE 29.—A reinforced concrete spandrel step 4 ft. 6 in. long is to be reinforced with three $\frac{3}{8}$-in. bars. The bars are to be hooked at each end and to have a cover of $\frac{3}{4}$ in. at each end. What is the weight of reinforcement?

Solution.—The length L as indicated in the diagram of *Table* XIV is 4 ft. 6 in. $-$ 2 $\times$ $\frac{3}{4}$ in. = 4 ft. 4$\frac{1}{2}$ in. From *Table* XIV the extra to allow for two hooks is 7 in. The overall length of one rod is

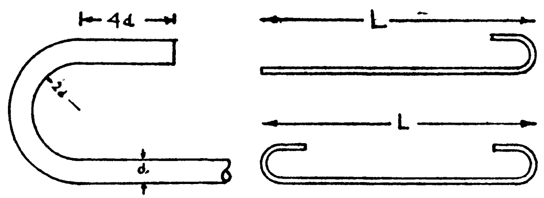
$$4 \text{ ft. } 4\tfrac{1}{2} \text{ in.} + 7 \text{ in.} = 4 \text{ ft. } 11\tfrac{1}{2} \text{ in.}$$

The weight of $\frac{3}{8}$-in. bar (from *Table* XIII) is 0·376 lb. per linear foot. The total weight is 3 $\times$ 4 ft. 11$\frac{1}{2}$ in. $\times$ 0·376 lb. = 5·6 lb.

TABLE XIII.

SECTIONAL AREA OF CIRCULAR BARS (Sq. In.)											WEIGHT (Lbs)	
Dia. In.	NUMBER OF BARS										Dia. In.	Per Foot
	1	2	3	4	5	6	7	8	9	10		
1/4	0·049	0·098	0·147	0·196	0·245	0·294	0·343	0·392	0·441	0·491	1/4	0·167
5/16	0·076	0·153	0·230	0·306	0·383	0·460	0·536	0·613	0·690	0·767	5/16	0·261
3/8	0·110	0·220	0·331	0·441	0·552	0·662	0·772	0·883	0·993	1·104	3/8	0·376
7/16	0·150	0·300	0·450	0·601	0·751	0·901	1·052	1·202	1·352	1·503	7/16	0·511
1/2	0·196	0·392	0·588	0·785	0·981	1·177	1·374	1·570	1·766	1·963	1/2	0·668
9/16	0·248	0·497	0·745	0·994	1·242	1·491	1·739	1·988	2·236	2·485	9/16	0·845
5/8	0·306	0·613	0·920	1·227	1·534	1·840	2·147	2·454	2·761	3·068	5/8	1·043
11/16	0·371	0·742	1·113	1·484	1·856	2·227	2·598	2·969	3·340	3·712	11/16	1·262
3/4	0·441	0·883	1·325	1·767	2·209	2·650	3·092	3·534	3·976	4·418	3/4	1·502
13/16	0·518	1·037	1·555	2·074	2·592	3·111	3·629	4·148	4·665	5·185	13/16	1·763
7/8	0·601	1·202	1·803	2·405	3·006	3·607	4·209	4·810	5·411	6·013	7/8	2·044
15/16	0·690	1·380	2·070	2·761	3·451	4·141	4·832	5·522	6·212	6·903	15/16	2·347
1	0·785	1·570	2·356	3·141	3·927	4·712	5·497	6·285	7·068	7·854	1	2·670
1 1/16	0·886	1·772	2·659	3·545	4·432	5·318	6·204	7·091	7·977	8·864	1 1/16	3·012
1 1/8	0·994	1·988	2·982	3·976	4·970	5·964	6·958	7·952	8·946	9·940	1 1/8	3·380
1 3/16	1·107	2·215	3·322	4·430	5·537	6·645	7·752	8·860	9·967	11·075	1 3/16	3·764
1 1/4	1·227	2·454	3·681	4·908	6·136	7·363	8·590	9·817	11·044	12·272	1 1/4	4·172
1 5/16	1·353	2·706	4·059	5·412	6·765	8·118	9·471	10·824	12·177	13·530	1 5/16	4·600
1 3/8	1·484	2·969	4·454	5·939	7·424	8·909	10·394	11·879	13·364	14·849	1 3/8	5·049
1 7/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 7/16	[illegible]

TABLE XIV.—Additional Length for Hooked Ends.



Diameter of bar in.	Add to L for One hook	Add to L for Two hooks	External diameter of hook	Diameter of bar	Add to L for One hook	Add to L for Two hooks	External diameter of hook
	in.	ft in.	in.	in.	ft in.	ft in.	in.
1/4	2½	4½	1½	13/16	7½	1-2½	4⅞
5/16	3	6	1⅞	7/8	8	1-3½	5¼
3/8	3½	7	2¼	15/16	8½	1-5	5⅝
7/16	4	8	2⅝	1	9	1-6	6
1/2	4½	9	3	1⅛	10	1-8	6¾
9/16	5	10	3⅜	1¼	11½	1-10½	7½
5/8	6	11½	3¾	1⅜	1-0½	2-0½	8¼
11/16	6½	1-0½	4⅛	1½	1-1½	2-3	9
3/4	7	1-1½	4½				

EXAMPLE 30.—A reinforced concrete beam 12 ft. long, 9 in. wide, and 15 in. deep is to be reinforced with two $\frac{5}{8}$-in. bars and two $\frac{3}{4}$-in. bars at the bottom with hooked ends, and three $\frac{7}{16}$-in. straight bars at the top. Fifteen stirrups $\frac{1}{4}$ in. diameter are required, each 2 ft. 7 in. long. The cover at each end is 1 in. Find the weights of bars of each diameter.

Solution.—The length *L* of the top bars is 12 ft. − 2 in. = 11 ft. 10 in. The $\frac{5}{8}$-in. bars will be 11 ft. 10 in. + 11½ in. = 12 ft. 9½ in. long. The $\frac{3}{4}$-in. bars will be 11 ft. 10 in. + 1 ft. 1½ in. = 12 ft. 11½ in. long. The weight is calculated as follows:

			lb.
$\frac{3}{4}$-in. bars—	2 × 12 ft. 11½ in.	× 1·502 =	39
$\frac{5}{8}$-in. ,,	2 × 12 ft. 9½ in.	× 1·043 =	26¾
$\frac{7}{16}$-in. ,,	3 × 11 ft. 10 in.	× 0·511 =	18⅛
$\frac{1}{4}$-in. ,,	15 × 2 ft. 7 in.	× 0·167 =	6½

The correct calculation of quantities of reinforcement has a very important effect on the price of an article. It has often been said that orders are obtained or lost by the errors in the calculation of quantities

of steel, and there is truth in this particularly when no quantities of steel are specified and the estimator has to assess what he thinks is adequate. The correct design of steel reinforcement for a reinforced concrete member is very complicated, and should only be undertaken by experienced engineers or by an estimator who has a sound knowledge of reinforced concrete design. There are many excellent books on reinforced concrete design, and the reader is recommended to study these for further knowledge on the subject.

CHAPTER XVI

REINFORCEMENT MATERIAL AND LABOUR COSTS

Steel Costs.

As was previously mentioned, it is desirable to list weights of steel reinforcement under the headings of various diameters, because the cost of steel increases for smaller sizes.

Reinforcement can either be bought direct from mills, or from local merchants. The advantages derived from purchasing direct from mills are that the cost is less, the bars can be ordered cut to lengths from 5 ft. to 40 ft., with a 2-in. margin at no extra cost, and as a rule the bars are reasonably free from rust. On the other hand it takes longer for deliveries to be made from mills, so that it may be necessary to order from the nearest merchant, in which event the cost is greater.

Taking the price of mild steel bars delivered at works by rail within the free cartage area in England and Wales at £17 2*s*. per ton basis (the basis being $\frac{5}{8}$-in. diameter and up), the price differential is as follows :

Diameter in inches.		£	*s*.
$\frac{9}{16}$, $\frac{1}{2}$, $\frac{7}{16}$	add 10*s*. per ton =	17	12
$\frac{3}{8}$	add 20*s*. per ton =	18	2
$\frac{5}{16}$	add 30*s*. per ton =	18	12
$\frac{1}{4}$	add 40*s*. per ton =	19	2
$\frac{3}{16}$	add 60*s*. per ton =	20	2

The prices from merchants are usually £2 to £3 per ton more than mill prices, plus additional charges for transport. To these charges must be added the cost of unloading, but as a rule it will be found convenient in costing to keep all such labour items with other indirect charges.

Waste and Rolling Margin.

If time permits the ordering from mills of larger diameter bars cut to lengths the percentage of waste will be negligible, but often in practice stocks of steel in long lengths are maintained for cutting to any desired length. The larger-diameter bars then produce a greater percentage of waste than small-diameter bars because short ends of thin bars have many uses. An average percentage to add for waste is $7\frac{1}{2}$, and in addition $2\frac{1}{2}$ per cent. should be added for rolling margin down to $\frac{3}{8}$ in. diameter and 4 per cent. for $\frac{3}{8}$ in. and under.

Lapping.

It is not often that the reinforcement of pre-cast concrete products needs to be lapped, but when it is required a minimum of 40 diameters should be added for the lap.

Binding Wire.

As a rule 16-gauge wire is used, but the weight of it in any particular unit is so small that it is seldom worth while to calculate it. The cost of binding wire should be added to the general overhead charges.

Electrodes.

As in the case of binding wire, the additional weight per unit is so small that the cost should be added to the general overhead charges.

Coiled Steel.

Mild steel up to $\frac{5}{16}$ in. diameter can be supplied in 1-cwt. to 2-cwt. coils, at less cost than straight bars. To this, however, must be added the cost of straightening, which can be done either by roughly straightening in the hands and then hammering out the kinks on a bench, or by a machine designed for the purpose, which can also be mounted with a cutter, so that as the steel passes out straightened it can be cut to the required length. Although the percentage of waste is reduced by using coiled steel it is not particularly satisfactory for use as main reinforcement in concrete products, because as a rule a concrete cover of $\frac{1}{2}$ in. to $\frac{3}{4}$ in. is required, and the straightened coiled steel retains a certain amount of spring in it which tends to distort, thereby reducing the cover of concrete. It is most satisfactorily employed as distribution steel in floor and roof slabs, walls, etc., and is also useful in short lengths for forming stirrups, and in continuous lengths for forming helical binding for columns and piles. The time of straightening $\frac{3}{16}$-in. to $\frac{5}{16}$-in. coiled mild steel is 2 to 3 hours per cwt.

There are several special types of reinforcement available, in the form of meshes and distorted bars, and high-tensile steel is sometimes used. Full details are given in the makers' catalogues. The principal applications of mesh reinforcement are in slabs, cable covers, manhole covers, lettering for traffic signs, shelves to refrigerator cabinets, pipes, posts and struts for billhoardings, and cable ducts and covers.

Labour Charges.

The general practice in estimating steel costs for simple reinforced concrete castings is to use a figure which includes the cost of material,

the labour in cutting, bending and assembling into a simple frame, and profit and overheads. These prices are as follows:

$\frac{5}{8}$ in. diameter and upwards	27s. 6d.	per cwt., say,	3d. per lb.
$\frac{3}{8}$ in. diameter up to $\frac{5}{8}$ in.,	30s. to 35s.	" " "	$3\frac{1}{2}$d. " "
$\frac{1}{4}$ in. and $\frac{3}{16}$ in. diameter,	37s. 6d.	" " "	4d. " "

This method of pricing reinforcement is quick, and if anything errs on the side of safety for diameters over $\frac{5}{8}$ in., but for large contracts when close estimates are being prepared, and for small diameters, it is better to go into more detail. The prices per pound of fabricated reinforcement frames of diameters $\frac{3}{8}$ in. and under increase very rapidly for rods cut in short lengths, with complicated bending, and closely-spaced stirrups which are tied to the main bars. The average inclusive price may easily exceed 4d. per pound. The analysis of labour charges given in *Table* XV is helpful in compiling more accurate estimates of fabricated reinforcement frames. The time rates given slightly exceed those of fabricating reinforcement for buildings, and the explanation is that as a rule concrete products require reinforcement in shorter lengths, and for a given weight there is more bending.

TABLE XV.—Steel Reinforcement Time Rates.

Diam.	All handling and cutting to length	Average bending including up to 2 hooks and 2 cranks	Hand ties with 16G. wire including assembly on jigs	Welds including assembly on jigs
In.	Cwt. per hour	Cwt. per hour	Number per hour	Number per hour
5/8	2·7	1·4	65	110
9/16	2·5	1·3		
1/2	2·3	1·1		
7/16	2·1	1·0		
3/8	2·0	0·9		
5/16	1·8	0·8		
1/4	1·5	0·7		
3/16	1·4	0·65		

Welded Reinforcement.

Arc welded reinforcement frames are very superior to tied frames. Not only is a welded frame stronger, which enables it to withstand transport much better, but it is quicker to fabricate, as will readily be

appreciated by a comparison of the number of wire ties and welds that can be done in an hour, quoted in *Table* XV. In many cases, also, hooks to main bars can be dispensed with, and in practically every instance the hooks or lapping of stirrups can be avoided. The result is a better reinforcement frame at less cost.

If a factory is not equipped to bend and fabricate its own reinforcement, prices for complete frames can be obtained from firms specialising in this work. When the reinforcement frames are too awkward in shape, or too slender, to be satisfactorily transported between the two works, the specialists will usually be prepared to assemble the frames at the products factory.

EXAMPLE 31.—A floor beam 6 in. wide, 5 in. deep, and 8 ft. long is to be reinforced with two $\frac{5}{16}$-in. bars with hooked ends in the bottom and one $\frac{1}{4}$-in. straight bar in the top, with five $\frac{1}{8}$-in. links 1 ft. 2 in. long wired on at equal spaces. If the inclusive cost of labour and material including overheads and profit be taken at 4*d*. per lb., estimate the cost of reinforcement per square yard. Allow 10 per cent. for waste and rolling margin.

Solution.—First calculate the weight of reinforcement in a single beam (*Table* XIII).

	lb.
$\frac{5}{16}$-in. bars—2 No. (7 ft. 11 in. + 6 in. for two hooks) = 16 ft. 10 in. × 0·261 lb. per ft.	= 4·39
$\frac{1}{4}$-in. bars—1 No. 7 ft. 11 in. × 0·167 lb. per ft.	= 1·32
$\frac{1}{8}$-in. links—5 No. 1 ft. 2 in. long = 5 ft. 10 in. × 0·043 lb. per ft.	= 0·25
Total	5·96
Add 10 per cent. for waste and rolling margin	0·59
	6·55

$$\text{One beam covers an area of 8 ft.} \times \frac{6 \text{ in.}}{12} = 4 \text{ sq. ft.}$$

$$\text{Therefore the weight of steel per square yard is } \frac{6\cdot55}{4} \times 9 = 14\cdot74 \text{ lb.,}$$

and the cost is 14·74 lb. × 4*d*. = 4*s*. 11*d*. per square yard.

EXAMPLE 32.—A beam 17 ft. long is to be reinforced in the bottom with six $\frac{3}{4}$-in. bars with hooked ends and in the top with four $\frac{1}{2}$-in. straight bars, with 19 $\frac{1}{4}$-in. stirrups each 4 ft. 7 in. long. Allow 1 in. for cover and 10 per cent. for waste and rolling margin. Estimate the approximate cost of reinforcement at 3½*d*. per lb. inclusive of materials, labour, overheads, and profit.

Solution.—Weight of reinforcement:

		lb.
$\frac{7}{8}$-in. bars—	6 No. (16 ft. 10 in. + 1 ft. $1\frac{1}{2}$ in. for two hooks) = 107 ft. 9 in. × 1·502 lb. per foot =	161·8
$\frac{1}{2}$-in. ,,	4 No. 16 ft. 10 in. = 67 ft. 4 in. × 0·668 lb. per foot =	45·0
$\frac{1}{4}$-in. ,,	19 No. 4 ft. 7 in. = 87 ft. 1 in. × 0·167 lb. per foot =	14·5
Total	. . . .	221·3
Add 10 per cent. for waste and rolling margin	. . .	22·1
		243·4

Approximate cost of reinforcement, 243·4 lb. × $3\frac{1}{2}d.$ = 71*s*.

EXAMPLE 33.—A sleeper is to be reinforced with a welded frame, which comprises a total weight of 34 lb. of steel. The reinforcement consists of 27 lb. of $\frac{3}{8}$-in. bars and 21 (weight 7 lb.) $\frac{3}{16}$-in. stirrups. Each frame has 156 welds. Estimate the actual cost of labour and materials, if steel benders and fixers are paid 1*s*. 9*d*. per hour, and welders 1*d*. per hour extra.

Solution.—This is an unusual frame, so it is advisable to compute the cost in detail.

The costs of steel are

$\frac{3}{8}$-in. bars, £18 2*s*. per ton delivered from mill;
$\frac{3}{16}$-in. ,, £20 2*s*. ,, ,, ,, ,, ,,

The analysis of the estimated cost per frame is as follows.

	s.	*d.*
Materials.—		
$\frac{3}{8}$-in. bars—27 lb. + $11\frac{1}{2}$ per cent. for waste and rolling margin = 30·1 lb. at £18 2*s*.	4	11·0
$\frac{3}{16}$-in. bars—7 lb. + $11\frac{1}{2}$ per cent. for waste and rolling margin = 7·8 lb. at £20 2*s*.	1	5·0
Labour.—		
$\frac{3}{8}$-in. bars:		
Handling and cutting 30·1 lb. at 2 cwt. per hour $= 30{\cdot}1 \times \dfrac{1s.\ 9d.}{2 \times 112} =$	0	2·8
Bending 30·1 lb. at 0·9 cwt. per hour $= 30{\cdot}1 \times \dfrac{1s.\ 9d.}{0{\cdot}9 \times 112} =$	0	6·3
$\frac{3}{16}$-in. bars:		
Handling and cutting 7·8 lb. at 1·4 cwt. per hour $= 7{\cdot}8 \times \dfrac{1s.\ 9d.}{1{\cdot}4 \times 112} =$	0	1·0
Bending 7·8 lb. at 0·65 cwt. per hour $= 7{\cdot}8 \times \dfrac{1s.\ 9d.}{0{\cdot}65 \times 112} =$	0	2·3
Welding, including setting up jigs, at 110 per hour, $= \dfrac{156}{110} \times 1s.\ 10d. =$	2	7·0
	9	11·4

The average per pound is $\dfrac{9s.\ 11d.}{34} = 3{\cdot}5d.$, but it must be remembered that no overheads or profit are included.

CHAPTER XVII

OVERHEAD CHARGES AND PROFIT

THE total cost of the items described in the preceding chapters, that is all the materials, and labour for casting, making moulds, and reinforcement, represents the prime cost of an article. In addition, there are expenses connected with the establishment which cannot be allocated as direct charges and, as they affect all contracts, the only satisfactory way of dealing with them is to add a charge to each contract, usually 30 to 40 per cent. on prime cost. The sum of all these charges is known as overhead, or establishment, charges. The items that make up overhead charges are:

Miscellaneous materials such as mould oil, petrol and oil for plant, small tools, protective clothing, and all material items which cannot be directly allocated conveniently to prime cost; plant depreciation, repairs, insurance of plant, taxes, interest, fuel and power, water, National Health and Unemployment Insurances, Workmen's Compensation, office salaries including managers, draughtsmen and clerks, directors' salaries and fees, bad debts, stationery, and all sundry office expenses such as postages, telephone, selling expenses and commissions, advertising, auditing, travelling, lighting and heating, rent, and capital charges.

Indirect labour charges represent a considerable proportion of overhead charges, but these have been dealt with separately under the respective labour charges.

There are various ways of allocating these charges to cost, but the two most usual methods are to make either (1) a percentage charge on prime cost or (2) a percentage charge on direct labour cost. The calculation of overhead charges by a percentage on prime cost is by far the simpler method, and until carefully-analysed labour costs are compiled it is the only method that can be adopted. There are, however, very decided limitations to this method in a factory manufacturing various types of units, because obviously the greater the material charges the greater becomes the overhead expense, but it does not follow that the overhead expenses should be proportionately more on a product involving greater material costs. The materials themselves only cause an overhead expense in connection with their purchase, storage, and capital outlay.

On the other hand, the use of plant, office and organising expenses,

rents, power, and in fact practically all the items previously enumerated, are necessitated by virtue of the labour employed. It is for this reason that the most satisfactory method of charging overhead expenses is by a percentage on direct labour charges. If the indirect charges are added separately the overhead charges represent about 100 to 120 per cent. on direct labour charges. While this method is more accurate it cannot be reliably used until exact data exist of direct labour charges, and even though the total direct labour cost may be ascertained in any period of time, there is still the problem of estimating the direct labour costs of all the various sizes, shapes, and finishes of products met with in a products factory for the purposes of compiling a quotation.

Then again it can never be known in advance whether the particular percentage to be used will be correct. In fact the figure can only be accurately calculated on past records. The actual value of a current percentage is indeterminate as its value is controlled entirely by the volume of orders. The lowest ratio of overhead charges to prime cost is reached when the orders represent the maximum output of the factory. The estimation of an overhead figure to add to prime cost requires the most careful consideration, and should not necessarily be a figure calculated from previous records. As a rule the greater the production the less becomes the percentage charge for overhead expenses. To increase production it may be decided to reduce the estimate of on-costs, and a small reduction may quite possibly result in a considerable increase in sales. On the other hand, the sales organisation can be increased, with the object of finding new markets and selling more products. Whilst this step would increase the total overhead expenses, if it were successful the increased production would result in a reduced unit on-cost.

It is advisable to be able to manufacture various articles for stock, as orders will fluctuate according to the demand and seasonal requirements. Provided there is a steady demand for standard products carried as stock, a fairly constant production can be maintained, which will materially assist in covering overhead charges and the more accurate estimation of them.

Profit.

Profit is the difference between all the outgoing expenses and the net price received for the articles. It is indeterminable in advance in the case of most factories, and can only be ascertained over a specified previous period by offsetting the entire cost including establishment charges against the net revenue for the same period, the difference being profit or loss as the case may be.

A profit cannot be made until all establishment charges are covered.

When an estimator adds overhead charges and then adds a profit in the compilation of a price, it means that the percentage of overhead charges has been increased by the profit. If orders can be obtained at such prices so well and good, but it must be borne in mind that whilst the principle of every transaction showing a profit is the only basis on which a business can expand, the overhead charges must be met before profit materialises. When the point is reached where all overhead charges are covered, profit then begins to accumulate at practically the same percentage on unit cost as overhead charges, i.e. 30 to 40 per cent.

From this it is obvious that if there is any doubt whether a price will result in an order, and provided always that the production over any two consecutive periods can be increased, it is advisable to accept an order without any separate addition for profit, relying on the increased production to provide the profit. Such a procedure is naturally left to the discretion of the management, although obviously the price will include a profit if this is possible.

The distribution of overhead charges presents a great difficulty when the volume of orders is likely to diminish. When a factory is working at full pressure the basic on-cost per unit may be low, but when production drops it increases. If the increased on-cost were charged in the prices, still fewer orders would be obtained; this would inevitably result in a loss, so that the question arises whether it would not be the better policy to reduce prices, and thereby increase sales, with the possibility of making a profit, or in any event of reducing the loss.

The total cost of overheads in a twelve months' period can be estimated in advance for most practical purposes; what cannot be ascertained in advance is the volume of production or sales. It is therefore very desirable, having decided what percentage is to be added for overheads, to be able to calculate the sales required to cover the total cost of overheads. An allowance for profit can also be made, and from the combined figures some indication can be obtained of the annual sales necessary to ensure a profit. This figure can be of the utmost value for, if it be calculated to a weekly output, records can be kept comparing the actual sales with those estimated, and steps can be taken in good time to see whether adjustment of price can ensure the production required to cover charges, at which stage profits begin to accumulate.

Sales Required to Show a Profit.

If the overhead charges for a current year are assessed at £10,000, it is required to ascertain the approximate sales necessary if 7½ per cent. profit is required on turnover. Competitive prices indicate that the

margin for overheads and profit should not exceed 40 per cent. on prime cost, therefore the allowance for overheads is $40 - 7\frac{1}{2} = 32\frac{1}{2}$ per cent.

The prime cost required to provide overhead charges of £10,000 if the entire margin of 40 per cent. is assumed to cover them in the first instance, is	£25,000
Add overheads (40 per cent.)	£10,000
	£35,000
Add haulage (estimated at 15 per cent. of £35,000), say	£5,300
	£40,300

The profit required is $7\frac{1}{2}$ per cent. on turnover but, as previously explained, profit does not begin to accumulate until all establishment charges are covered, and then it accumulates at the rate of approximately 40 per cent.

If x = total sales to provide $7\frac{1}{2}$ per cent. profit,
Then $0{\cdot}075x$ (that is, $7\frac{1}{2}$ per cent. of sales) = profit
and x − £40,300 = additional turnover necessary to provide the profit.
Therefore 40 per cent. of (x − £40,300) = $7\frac{1}{2}$ per cent. of x

$$0{\cdot}4x - 16{,}120 = 0{\cdot}075x,$$
$$0{\cdot}325x = 16{,}120,$$
$$\therefore\ x = £49{,}600.$$

The total annual sales should therefore be in the region of £49,600 which would provide a profit of $\frac{7{\cdot}5}{100} \times £49{,}600 = £3720$.

The weekly sales should be $\frac{£49{,}600}{52} = £950$ approximately.

The foregoing figures have to be estimated, but the method is a fairly reliable one of calculating a predetermined turnover, which can be of the utmost value as a quota to a sales manager. The sales figure to be aimed at for a factory of any size can be ascertained provided the following information is available:

(*a*) The total estimated overheads. This can be taken as for the previous year plus a small amount for extra power, capital charges, etc., in anticipation of increased production.

(*b*) The gross percentage to be added to estimates to cover overheads and profit. This figure is controlled to a great extent by anticipated demand.

(*c*) The annual profit expected.

CHAPTER XVIII

CARRIAGE CHARGES

Weight of Concrete Products.

CONCRETE PRODUCTS and cast stone can be despatched by rail or by road transport, but whichever is employed the carriage charges should be carefully assessed, and the weight accurately calculated as these charges are liable to represent a considerable percentage on the basic cost. The basic cost of concrete products varies from about 2*s.* per cubic foot for the very cheapest products to many shillings per cubic foot; a good average is about 4*s.* 6*d.* per cubic foot, where special mould making is required, with a fair amount of repetition. There are 16 cub. ft. of ballast concrete per ton, so that the value per ton varies from 2*s.* × 16 = £1 12*s.* to 4*s.* 6*d.* × 16 = £3 12*s.* per ton. The minimum cost of carriage is about 5*s.* per ton, so that the lowest percentage on a basic cost of 4*s.* 6*d.* per cubic foot is 7 per cent. The percentage increases as the value of the goods decreases, so that at 2*s.* a cubic foot the minimum addition for carriage is 16 per cent. The price of 5*s.* per ton for transport is, however, only adequate for a distance up to about five miles from works, so that it will be seen how important it is to estimate carriage charges correctly.

There are about 16 cub. ft. of concrete per ton, based on concrete weighing 144 lb. per cubic foot, but the weight is affected by the density of the aggregates, the proportions of the mixture, the quantity of water in the mixture, and the method adopted for compacting. A very wet 4 : 2 : 1 ballast concrete weighs approximately 135 lb. per cubic foot, while the same proportions of materials with enough water to form a concrete with 1-in. slump, which it would be necessary to vibrate into moulds, would weigh about 146 lb. per cubic foot. The weight of any concrete, however, can be calculated if the specific gravity of the materials is known, and the following example illustrates the method of arriving at the weight.

EXAMPLE 34.—If a concrete is composed of 90 lb. of Portland cement, 1·5 cub. ft. of sand, and 3 cub. ft. of $\frac{3}{8}$-in. ballast, and there are 6 gallons of water in the mix, including what is in the sand and aggregate, what is the weight per cubic foot of the concrete?

Solution.—The loose weight of cement is 90 lb. per cubic foot and its specific gravity is 3·14. The loose weight of sand is 108 lb. per cubic foot, that of $\frac{3}{8}$-in. ballast is 90 lb. per cubic foot, and the specific

gravity of both materials is 2·65. Water weighs 10 lb. per gallon and its specific gravity is 1.

Material.	Absolute volumes (cub. ft.).	Weight (lb.).
Cement	$\frac{90}{3\cdot14 \times 62\cdot4} = 0\cdot46$	90
Sand	$\frac{1\frac{1}{2} \times 108}{2\cdot65 \times 62\cdot4} = 0\cdot98$	162
Ballast	$\frac{3 \times 90}{2\cdot65 \times 62\cdot4} = 1\cdot63$	270
Water	$\frac{6 \times 10}{62\cdot4} = 0\cdot96$	60
	Totals . . 4·03	582

$$\text{Weight of concrete per cubic foot} = \frac{582 \text{ lb.}}{4\cdot03 \text{ cub. ft.}} = 144 \text{ lb.}$$

The effect on weight of compacting is controlled by the amount of water in the mix. The greater the quantity of water used in excess of that actually required completely to hydrate the cement and give the required workability, the less the weight per cubic foot of the concrete. Insufficient water in a mix to produce workability also reduces the weight of concrete because the concrete will be honeycombed.

Most aggregates used in this country for concrete products for structural purposes give a weight of finished concrete of 144 lb. per cubic foot, and this is also the figure recommended in most text-books. The figure is convenient to use because 1 sq. in. of concrete 1 ft. long weighs 1 lb. Thus a concrete section 5 in. × 10 in. weighs 50 lb. per linear foot. The area of the section in square inches gives the weight in pounds per linear foot. This rule is very useful, particularly when estimating the quantity of products required to give a load of specified weight, or it can be used for checking weights loaded on to hired transport. Reinforced concrete products weigh 150 lb. per cubic foot.

Weight of Cast Stone.

The calculations of the weight of cast stone for transport purposes by the process of net volumes is liable to be very laborious as so much of it is moulded, and it is therefore convenient to calculate overall

volumes and assess weight as an average of 18 cub. ft. per ton. The average price of cast stone is about 8*s*. per cubic foot and the percentage cost of transport at 5*s*. per ton is 3½ per cent. on basic cost. It will be appreciated, therefore, that there is no necessity for very close calculations of weight, unless the basic cost of the material is low.

Costs of Hired Transport.

Lorries can be hired by the hour, day, or week, but this method of hiring is not particularly satisfactory as there is no assurance that the work will be done at the cost per ton included in the estimate. The most satisfactory method is to obtain quotations at per ton, and then, provided the calculations of weight are accurate, the estimated cost of transport should be fairly near the actual cost. Small lorry loads of concrete products up to 4 tons capacity as a rule cost very much more per ton than loads of 6 tons to 8 tons, and to make the maximum economy the largest loads possible should be despatched. Sometimes, of course, with moulded or hollow blocks, or concrete products of awkward shape, it may not be possible to load a vehicle fully, as the space taken up by the products is the limiting factor, so that whilst it may be necessary to use a 6-ton or 8-ton lorry with a large platform to transport the material, the lorry may only be loaded to half capacity by weight. This is a contingency which should be anticipated when estimating.

An approximate guide to average haulage charges is:

Up to 5 miles	5*s*. 0*d*. per ton minimum
,, ,, 10 ,, ...	6*s*. 6*d*. ,, ,, ,,
,, ,, 15 ,, ...	8*s*. 0*d*. ,, ,, ,,
,, ,, 20 ,, ...	9*s*. 6*d*. ,, ,, ,,

These prices include a small profit, but if an actual rate from a haulage contractor is obtained at the time of estimating a profit should be added of 7½ to 10 per cent.

Mobile and overhead cranes reduce the time of loading considerably, and as a rule a haulage contractor expects his lorry to be loaded and away within one hour of arriving at the factory, so that, if no mechanical plant is available for loading, the manufacturer would have to expect to pay more for transport. If hired lorries are held up at the factory due to congestion of lorries waiting to be loaded, claims would no doubt be made for standing time. Claims would also be made if the lorry was kept for more than one hour at the site, though as a rule when this happens it is the fault of the contractors, and a counter-claim can be made. The cost of standing time for a lorry and driver is 10*s*. to 15*s*. per hour.

It is customary to expect the contractor to unload the material at the site, and when dealing with established building contractors it is seldom necessary to state this in a quotation. Some customers, however, may not be aware of this custom, and do not employ labourers for unloading; a case in point is delivery at a private residence, so that either the customer must be advised at the time of quoting that he is expected to provide men for unloading, or the manufacturer must include charges for men's time in going to the site to unload. It is advisable to be certain that a haulage contractor whose lorries are hired is insured against damage or loss to the material being transported.

The checking of tonnage charged by a haulage contractor is important. This can be done by a calculation of the net volume of concrete products in the load multiplied by the calculated weight per cubic foot of the particular concrete. For the cost of a few hundred pounds a motor-wagon weighbridge can be installed, and this is a good investment, particularly when the high percentage that transport represents on basic cost is borne in mind. Not only can haulage accounts be easily checked, but lorries can be loaded to full capacity, and all incoming materials bought by weight can be checked.

Transport Owned by the Manufacturer.

Capital invested in motor lorries is a good investment for the manufacturer, and should show a good margin of profit. It is advisable when calculating the number of vehicles and tonnage required never to exceed the minimum average tonnage which has been produced in a period of, say, one month, otherwise there may be a possibility of vehicles being idle, when the standing charges will very quickly accumulate.

One of the greatest benefits of owning vehicles is that drivers can be educated in the safe loading and unloading of concrete products, and thus by their supervision avoid much damage which might otherwise occur. Supervision is particularly important at the site, because most reinforced concrete products have to be handled in a certain way to avoid breakage. As a rule the reinforcement should always be at the bottom of the casting when lifting, and it helps safe handling to mark the top of a unit "TOP" in large letters. There are times, however, in handling long rectangular units such as floor or roof beams reinforced at the bottom corners, when it may be desirable to lift on the side, if a much greater depth is obtained this way, because although only one bar would then be at the bottom, the increased depth would add greatly to the strength.

The most satisfactory way to calculate transport costs is to estimate the standing charges of the vehicle, such as depreciation, interest on

capital, driver's wages, taxes, insurances, garage, overheads, repairs, etc., and reduce these to a daily charge. The petrol and oil consumption of a vehicle will be known, so that the cost of a journey of any distance can be calculated by dividing the daily standing charge by the number of trips that can be made in a day and adding the cost of petrol, oil, and expenses. This calculation gives the total running cost for the vehicle to which profit should be added; dividing by the capacity of the vehicle gives the cost per ton. The number of trips that can be made in a period depends on the speed, which usually averages 12 to 15 miles per hour when maximum speed is 20 miles per hour, the time taken in loading and unloading, and the length of the working day. The law prescribes that no driver shall work longer than eleven hours per day, and shall not drive for a continuous period longer than five hours without rest. The number of days that will be taken on a long journey can also be calculated from this information, bearing in mind that expenses may include board and lodging for the driver and additional garage expenses for the vehicle.

The most satisfactory method of setting out an estimate of running costs is as follows:

	£	s.	d.
Depreciation per annum at $\frac{1}{5}$th of purchase price . . .			
Interest per annum on capital outlay at 5 per cent. of purchase price			
Driver's wages, and mate if employed, per annum . . .			
Employer's proportion of Health and Unemployment Insurance, per annum			
Licence and registration annual charges as *Table* XVI (or current rates)			
Insurance of vehicle, per annum			
Insurance of load (optional), per annum			
Insurance for Workmen's Compensation			
Garage costs per annum			
Tyres (the approximate mileage to expect from tyres can be obtained from tyre manufacturers)			
Overheads			
Repairs. (This estimate can only be made from experience. If no records exist upon which to base a more accurate figure, 50 per cent. of the depreciation figure may be taken.) .			
Total standing charges			

$$\text{Standing charges per day} = \frac{\text{Total standing charges}}{52 \text{ weeks} \times 5\frac{1}{2} \text{ days}}$$

$$\text{Standing charges per trip} = \frac{\text{Standing charges per day or per week}}{\text{Number of trips made}}$$

Estimated cost per load:	£ s. d.
Standing charges per trip	
Petrol (divide the mileage of trip both ways by average miles per gallon = number of gallons at per gallon) . .	
Oil (divide the mileage of trip both ways by the average miles per gallon = number of gallons at per gallon) . .	
Driver's expenses	
Profit	
Total cost per load	

Estimated cost per ton

$$= \frac{\text{Total cost per load}}{\text{Tons of goods loaded}} = \qquad \text{per ton.}$$

TABLE XVI.—Licence and Registration Charges (1942) for Goods Vehicles (Petrol, Heavy Oil, etc.).

		Annual licences, expiring on Dec. 31st. Full duty. £	s.	d.	Quarterly licences. Full duty. £	s.	d.
Not exceeding 12 cwt. in weight unladen . .		10	0	0	2	15	0
Exceeding 12 cwt. but not exceeding 1 ton in weight unladen		15	0	0	4	2	6
Exceeding 1 ton but not exceeding 1½ tons in weight unladen		20	0	0	5	10	0
Exceeding 1½ tons but not exceeding 2 tons in weight unladen		25	0	0	6	17	6
Exceeding 2 tons but not exceeding 2½ tons in weight unladen	Fitted entirely with pneumatic tyres	30	0	0	8	5	0
	Other vehicles	40	0	0	11	0	0
Exceeding 2½ tons but not exceeding 3 tons in weight unladen	Fitted entirely with pneumatic tyres	35	0	0	9	12	6
	Other vehicles	46	13	4	12	16	8
Exceeding 3 tons but not exceeding 4 tons in weight unladen	Fitted entirely with pneumatic tyres	50	0	0	13	15	0
	Other vehicles	66	13	4	18	6	8
For each additional ton or part of a ton in excess of 4 tons	Fitted entirely with pneumatic tyres	20	0	0	5	10	0
	Other vehicles	26	13	4	7	6	8
If the vehicle is used for drawing a Trailer (additional duty)	Where the weight of the vehicle unladen does not exceed 2½ tons . .	10	0	0	2	15	0
	Where the weight of the vehicle unladen exceeds 2½ tons but does not exceed 4 tons . .	15	0	0	4	2	6
	Where the weight of the vehicle unladen exceeds 4 tons	20	0	0	5	10	0

Once the calculation has been made for standing charges the same figure can remain in use for twelve months, so that if petrol, oil, and profit costs are calculated, a standard chart showing rates per ton for various mileages could be produced. Within the limits of a legal driving day it is not possible to do journeys much over 75 to 100 miles one way (150 to 200 miles both ways), and driver's expenses are not incurred unless by arrangement. Over this mileage, however, expenses must be included for board, lodging, meals, garage, etc.

Rail Transport.

The transport of concrete blocks by rail often costs less than road transport, and as a rule the greater the distance the greater becomes the economy. Unfortunately, however, it is fairly general experience that products despatched by rail sustain a greater proportion of damage than when despatched by road transport.

The transport rates can be obtained from railway offices, and in the case of concrete products usually include station to station only. To this rate must be added the cost of road transport from the works to the station, the cost of unloading and packing into wagons, and the cost of packing material, such as timber bearers, straw, etc. From the station to which the material is consigned delivery has to be made to the site. This will often be undertaken by the railway if within their normal cartage area, otherwise it is as well to leave the customer to arrange collection as he will have better facilities for arranging transport.

Some types of products, such as moulded concrete blocks or cast stone, are more subject to damage in railway trucks no matter how carefully the packing may be done. This is usually due to excessive jolting of the trucks in motion and in shunting, and the additional handling in loading and unloading from lorry to wagon. If it is desirable to despatch such material by rail it is safer to pack it into containers. By special arrangement the railway company will deliver the container to the works where it has to be loaded immediately, and the products arrive at the site in the same container. The advantages of containers are that the packing can be done at the works under supervision, and the additional handling necessary in unloading at station and loading into wagon, unloading at destination and loading on to lorry, is avoided.

CHAPTER XIX

EXAMPLES OF CO-ORDINATING ESTIMATES

Concrete Posts.

EXAMPLE 35.—Estimate the cost of a reinforced concrete post as illustrated in *Fig.* 40 in quantities of 5, 20, and 100. The dimensions of the post are 6 in. square at the base tapering to 3 in. square at the top and

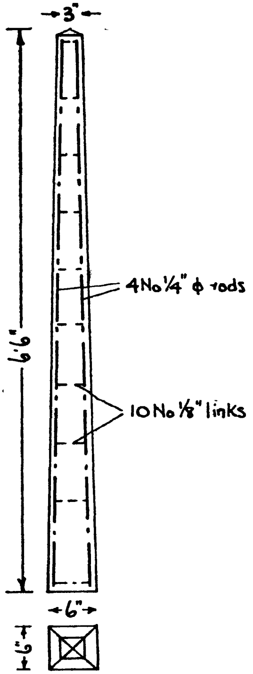


Fig. 40.

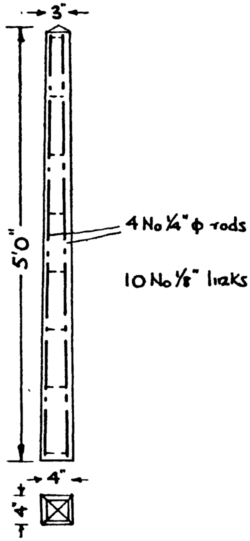


Fig. 41.

6 ft. 6 in. high. The reinforcement consists of four $\frac{1}{4}$-in. bars with ten $\frac{1}{8}$-in. links tied with 16-gauge wire. Delivery is to be made ten miles from the works. The concrete is to be in the proportions of 3 cub. ft. of $\frac{3}{8}$-in. shingle to 2 cub. ft. of sand to 90 lb. of Portland cement.

The prices of materials delivered at works are:

$\frac{3}{8}$-in. shingle . .	9s. 6d. per cubic yard;
Sand . . .	12s. 6d. ,, ,, ,, ;
Portland cement .	60s. 0d. per ton including non-recoverable bag charge;
Reinforcement . .	£17 2s. 0d. per ton basis.

Wages per hour: Mould-makers, 2s.; Concrete casters, 1s. 7d.; Labourers, 1s. 6d.; Steel benders and fixers, 1s. 10d.

Net volume of post $= (A_t + A_b + \sqrt{A_t A_b})\frac{h}{3}$, and when

$$A_t = \frac{3 \text{ in.} \times 3 \text{ in.}}{144} = 0{\cdot}063 \text{ sq. ft.}; \quad A_b = \frac{6 \text{ in.} \times 6 \text{ in.}}{144} = 0{\cdot}25 \text{ sq. ft.},$$

and $h = 6$ ft. 6 in.

$$= (0{\cdot}063 + 0{\cdot}25 + \sqrt{0{\cdot}063 \times 0{\cdot}25})\frac{6 \text{ ft. } 6 \text{ in.}}{3}$$

$$= (0{\cdot}063 + 0{\cdot}25 + 0{\cdot}125)2{\cdot}17$$
$$= 0{\cdot}438 \times 2{\cdot}17 = 0{\cdot}95 \text{ cub. ft.}$$

(*See page* 99 *for Analysis of Estimate.*)

The quantities do not warrant close calculations, so at an average price of 4*d.* per lb. for labour and material the cost of reinforcement is

$$4{\cdot}75 \text{ lb.} \times 4d. = 1s.\ 7d. \text{ per post.}$$

The selling price of the posts including reinforcement would be:

Quantities of 5 posts	13*s.* 7*d.* each
Quantities of 20 posts	9*s.* 8*d.* ,,
Quantities of 100 posts	6*s.* 5*d.* ,,

Where possible, post sizes should be standardised, but when a special size has to be made with only a few casts from a mould the example illustrates how rapidly the prices increase for small quantities, due to mould costs.

Effect of Volume on Prices of Posts.

When posts are very slender and of no great height the basic price rapidly increases, as the following example illustrates.

EXAMPLE 36.—Estimate the cost of a reinforced concrete post, as illustrated in *Fig.* 41, 4 in. square at the base, tapering to 3 in. square at the top by 5 ft. high, in quantities of 100 and estimating 50 castings

Analysis of Estimate.

		Basic cost per cubic foot.		
		5 Posts	20 Posts	100 Posts
Concrete materials (from *Table* II):		*s.* *d.*	*s.* *d.*	*s.* *d.*
⅜-in. shingle, 0·77 cub. yd. at 9*s.* 6*d.* =	7*s.* 4*d.*			
Sand, 0·52 cub. yd. at 12*s.* 6*d.* =	6*s.* 6*d.*			
Cement, 640 lb. at 60*s.* 0*d.* a ton =	17*s.* 2*d.*			
Cost per cubic yard	31*s.* 0*d.*			
Waste, add 5 per cent., say,	1*s.* 6*d.*			
	32*s.* 6*d.*			
Cost per cubic foot = $\frac{32s.\ 6d.}{27}$ =	1*s.* 2·5*d.*	1 2½	1 2½	1 2½
Labour:				
Casting from *Table* VII is .	38 m.p.c.			
Placing reinforcement + 10 per cent.	4 ,,			
Mixing	2 ,,			
From *Table* VIII, at 1*s.* 7*d.* per hour	44 ,,	1 2	1 2	1 2
Indirect charges, add 43 per cent. of 38 m.p.c. = 16 m.p.c. at 1*s.* 6*d.* per hour .		0 4¾	0 4¾	0 4¾
Labour and material:				
Moulds 5 off per mould for 5 posts 10 ,, ,, ,, ,, 20 posts 50 ,, ,, ,, ,, 100 posts and from *Table* XII . . .		6 0	3 0	0 7
		8 9¼	5 9¼	3 4¼
Overhead charges and profit, say, 40 per cent.		3 6	2 3¾	1 4
		12 3¼	8 1	4 8¼
Delivery at 6*s.* 6*d.* per ton = $\frac{6s.\ 6d.}{16}$ = 5*d.* per cubic foot . .		0 5	0 5	0 5
Basic cost per cubic foot		12 8¼	8 6	5 1¼
Cost per post of 0·95 cub. ft. volume . .		12 0 each	8 1 each	4 10 each

Reinforcement.—
Four bars 6 ft. 4 in. long by ¼-in. diameter = 25 ft. 4 in. at 0·167 lb. per foot = 4·25 lb.
Ten links average 1 ft. 3 in. long by ⅛-in. diameter = 12 ft. 6 in. at 0·04 lb. per foot = 0·50 ,,

4·75 lb.

from a mould. The cost of materials to be the same as in the previous example, and the reinforcement to consist of four ¼-in. bars and eight ⅛-in. links.

Net volume of post $= (A_t + A_b + \sqrt{A_t A_b})\frac{h}{3}$, and when

$A_t = \frac{3 \text{ in.} \times 3 \text{ in.}}{144} = 0{\cdot}063$ sq. ft.; $A_b = \frac{4 \text{ in.} \times 4 \text{ in.}}{144} = 0{\cdot}11$ sq. ft.,

and $h = 5$ ft.

$$= (0{\cdot}063 + 0{\cdot}11 + \sqrt{0{\cdot}063 \times 0{\cdot}11})\frac{5}{3}$$

$$= (0{\cdot}063 + 0{\cdot}11 + 0{\cdot}083)1{\cdot}66$$

$$= 0{\cdot}256 \times 1{\cdot}66 = 0{\cdot}426 \text{ cub. ft.}$$

Analysis of Estimate.

		Basic cost per cubic foot. s.	d.
Concrete materials: As previous example		1	2½
Labour:	m.p.c.		
Casting (from *Table* VII),	73		
Placing reinforcement + 10 per cent.	7		
Mixing	2		
From *Table* VIII at 1*s*. 7*d*. per hour	82	2	2
Indirect charges, add 43 per cent. of 73 m.p.c. = 31 m.p.c. at 1*s*. 6*d*. per hour		0	9
Moulds: From *Table* XII, for 50 castings from a mould .		1	2
		5	3½
Overhead charges and profit, say, 40 per cent. . . .		2	1½
		7	5
Delivery, as before		0	5
		7	10

Note that the basic cost per cubic foot of the larger post of 0·95 cub. ft. given in the previous example for 50 castings from a mould is 5*s*. 1½*d*.

Reinforcement: Four ¼-in. bars 4 ft. 10 in. long = 19 ft. 4 in. at 0·167 lb. per foot = 3·23 lb.

Eight ⅛-in. links average 1 ft. 3 in. long = 10 ft. × 0·04 lb. per foot = 0·4 lb.

3·63 lb.

		s.	d.
Estimated cost per post:			
0·426 cub. ft. at 7s. 10d.	=	3	4
3·63 lb. reinforcement at 4d. lb.	=	1	2½
		4	6½

When detailed estimates have been compiled for posts of various sizes and the moulds are retained as stock, it is useful to tabulate the results of estimates graphically with volume, so that all the intermediate values of various sizes of posts, provided the quantities are large, can be seen at a glance.

Post Spurs.

EXAMPLE 37.—It is proposed to manufacture and stock reinforced concrete spur posts, as illustrated in *Fig.* 42, 4 ft. high by 5 in. wide by 3½ in. thick, with two ½-in. diameter bolt holes, the reinforcement

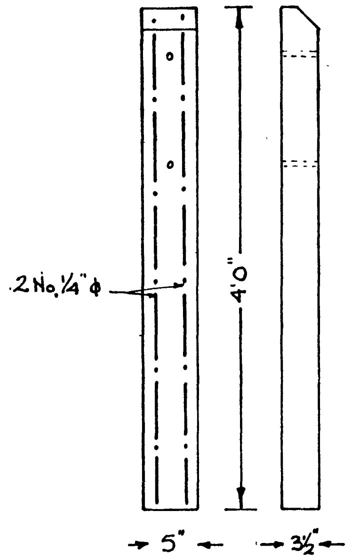


Fig. 42.

to consist of two ¼-in. bars. If it is anticipated that 50 castings can be produced from each mould, what is the price ex works? If the selling price is to include 25 per cent. discount to the retailer, what extra should be added to the price? The concrete mix is to be 3 cub. ft. of ⅜-in. shingle, 1½ cub. ft. of sand, and 90 lb. of Portland cement, the

cost of which can be taken at 1s. 3*d*. per cubic foot. Rates of pay per hour: Makers, 1s. 6*d*.; labourers, 1s. 5*d*.; mould makers, 2s.

$$\text{Net volume of spur} = \frac{5 \text{ in.} \times 3\tfrac{1}{2} \text{ in.}}{144} \times 4 \text{ ft.}$$
$$= 0{\cdot}49 \text{ cub. ft.}$$

Analysis of Estimate.

			Basic cost per cubic foot. s. d.
Concrete materials (3 : $1\frac{1}{2}$: 1)			1 3
Labour:			
	m.p.c.		
Casting, from *Table* VII,	61		
Placing reinforcement	6		
Mixing	2		
From *Table* VIII, at 1s. 6*d*. per hour	69	=	1 9
Indirect charges: Add 43 per cent. of 61 m.p.c. = 26 m.p.c.			
at 1s. 5*d*. per hour		=	0 $7\frac{1}{2}$
Moulds: From *Table* XII, based on 50 casts per mould .			1 0
			4 $7\frac{1}{2}$
Overhead charges and profit, say, 40 per cent. . . .			1 $10\frac{1}{2}$
			6 6

	s. d.
Cost per spur = 0·49 cub. ft. × 6s. 6*d*.	= 3 2
Extra for reinforcement: Two $\frac{1}{4}$-in. bars (= 2 × 3 ft. 10 in. × 0·167 = 1·28 lb.); at 4*d*. per lb. cost is 1·28 × 4*d*.	= 0 5
Selling price of spur ex works	= 3 7

If 25 per cent. discount is to be quoted to the retailer, the selling price x per spur is calculated as follows:

$$\left(x - \frac{25}{100}x\right) = 3\ \ 7 \quad \text{(s. d.)}$$
$$\frac{75}{100}x = 3\ \ 7$$
$$x = \frac{3\ \ 7 \times 100}{75}$$
$$= 4\ \ 9\tfrac{1}{2}$$

The number of spurs per ton is $\dfrac{16}{0{\cdot}49} = 33.$

It was recommended in earlier chapters that an extra should be added for holes, but it will be found that, as the mould has the hole positions positively formed, the dowels or pins which pass through these holes can be placed so rapidly that the extra time does not warrant consideration.

Granolithic Concrete Steps (Solid).

EXAMPLE 38.—Estimate the cost per linear foot ex works of the following item.

120 lin. ft. of 11-in. × 7-in. pre-cast concrete steps, solid rectangular section, 4 ft. long with tread and riser finished with 1-in. thickness of granolithic composed of 3 cub. ft. of $\frac{3}{16}$-in. clean granite chippings, 2 cub. ft. of $\frac{1}{16}$-in. down granite chippings free from dust, and 2 cub. ft. (180 lb.) of cement. The core to be composed of 4 cub. ft. of $\frac{3}{8}$-in. ballast, 2 cub. ft. of sand, 90 lb. of Portland cement. The reinforcement to be two $\frac{3}{8}$-in. bars with hooked ends placed in the bottom.

Material prices, delivered works:

Portland cement	56*s.* per ton
$\frac{3}{16}$-in. clean granite chips	30*s.* ,, ,,
$\frac{1}{16}$-in. down do.	35*s.* ,, ,,
$\frac{3}{8}$-in. ballast	10*s.* ,, ,,
Sand	12*s.* 6*d.* per ton
Timber	£50 per standard
Reinforcement	3½*d.* per lb. cut and hooked.

Labour rates (per hour): Makers, 1*s.* 8*d.*; labourers, 1*s.* 6*d.*; mould makers, 2*s.*

cub. ft.

$$\text{Volume of step per linear foot} = \frac{11 \text{ in.} \times 7 \text{ in.}}{144} = 0{\cdot}535$$

$$\text{Volume of granolithic do.} = \frac{(11 \text{ in.} + 6 \text{ in.}) \times 1 \text{ in.}}{144} = 0{\cdot}118$$

$$\text{Volume of concrete core do.} = \frac{10 \text{ in.} \times 6 \text{ in.}}{144} = 0{\cdot}417$$

Analysis of Estimate.

Granolithic materials (From *Table* III) : the quantities for a 1 : 2½ mortar are 1050 lb. of Portland cement and 1·17 tons of granite per cubic yard. As the price varies for the different gradings of granite, the quantities can be split up in proportion.

Thus $\frac{3}{16}$-in. chips $\frac{1{\cdot}17}{2\frac{1}{2}} \times 1\frac{1}{2} = 0{\cdot}7$ ton

$\frac{1}{16}$-in. down $\frac{1{\cdot}17}{2\frac{1}{2}} \times 1 = 0{\cdot}47$,,

		£	s.	d.
1050 lb. Portland cement at 56*s.* per ton		1	6	3
0·7 ton $\frac{3}{16}$-in. granite chips at 30*s.* per ton		1	1	0
0·47 ton $\frac{1}{16}$-in. granite chips at 35*s.* per ton			16	5
Cost per cubic yard	=	3	3	8
Cost per cubic foot = $\frac{63s.\ 8d.}{27}$	=	0	2	4½
Concrete materials :				
505 lb. Portland cement at 56*s.* per ton	=	0	12	8
0·41 cub. yd. sand at 12*s.* 6*d.* per cubic yard	=	0	5	2
0·81 cub. yd. ⅜-in. ballast at 10*s.* per cubic yard	=	0	8	1
Cost per cubic yard	=	1	5	11
Cost per cubic foot = $\frac{25s.\ 11d.}{27}$	=	0	0	11½

Materials :

Granolithic, 0·118 cub. ft. × 2*s.* 4½*d.* = 3·37*d.* per lin. ft.
Concrete, 0·417 cub. ft. × 11½*d.* = 4·80*d.* ,, ,, ,,

Combined cost for 0·535 cub. ft. = 8·17*d.* ,, ,, ,,

	m.p.c.	Basic cost per cubic foot. s.	d.
Materials : 0·535 cub. ft. = 8·17*d.*, say		1	3½
Labour :			
Casting semi-wet rubbed finish as *Table* IX, for volume of 0·535 × 4 ft. = 2·14 cub. ft.	= 55		
Placing reinforcement	= 5		
Mixing	= 2		
Basic cost at 1*s.* 8*d.* per hour	62	1	8½
Indirect charges, add 43 per cent. of 55 m.p.c. = 24 m.p.c. at 1*s.* 6*d.* per hour	=	0	7¼
Moulds : Assuming 15 castings from each mould (see *Table* XII)	=	1	4
		4	11¼
Overhead charges and profit, say, 40 per cent.	=	1	11¾
		6	11

Cost per lineal foot = 0·535 × 6*s*. 11*d*.	=	3*s*. 8½*d*.
Reinforcement: 2 × 3 ft. 10 in. + 7 in. for hooks = 8 ft. 10 in. × 0·376 = 3·33 lb. at 3½*d*.	=	3*d*.
Ex works price per lineal foot	=	3*s*. 11½*d*.

In this example the labour has been based on a semi-wet process with rubbed finish. An alternative process would be wet-cast face-up, when the basic labour cost would be 27 m.p.c., to which should be added hard-trowelling time as given in *Chapter* X, that is, 5 minutes per square foot.

Granolithic Concrete Steps (Spandrel).

EXAMPLE 39.—Working to the previous specification for solid steps, and the same prices for labour and materials, estimate the cost per linear foot of the following item.

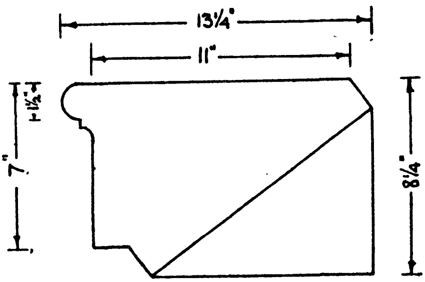


Fig. 43.

120 lin. ft. pre-cast reinforced concrete spandrel steps with moulded nosing, as in *Fig*. 43, 4 ft. long, with tread and riser finished with 1-in. granolithic. The steps are to be made face up, and reinforced with three ⅜-in. bars. Calculate the basic cost on the approximate net cube and adjust this figure to a basis to be used for pricing on overall cube.

	cub. ft.
The approximate net volume per linear foot is	0·46
The approximate volume of granolithic per linear foot is	0·127
The approximate volume of concrete backing per linear foot is	0·333
The overall volume per linear foot is	0·76
Approximate net volume per step is	1·84

Analysis of Estimate.

		Basic cost per cubic foot on net volume. s.	d.
Materials:			
Granolithic, 0·127 cub. ft. at 2*s.* 4½*d.*	= 3·63*d.*		
Concrete, 0·333 cub. ft. at 11½*d.*	= 3·85*d.*		
Cost per linear foot of 0·46 cub. ft.	= 7·48*d.*		
Cost per cubic foot, say		1	4½
Labour:	m.p.c.		
Casting by wet process, including placing reinforcement (see *Table* IX)	30		
Mixing	2		
Basic cost at 1*s.* 8*d.* per hour for . . .	32	0	10⅔
Indirect charges, add 43 per cent. of 30 m.p.c. = 13 m.p.c. at 1*s.* 6*d.* per hour		0	4
Moulds: The step has a moulded nosing, and the mould should be classed as "moulded." From *Table* XII, assuming 15 casts from each mould, the basis is	1*s.* 4*d.* cub. ft.		
Add 50 per cent. for moulded	8*d.* ,, ,,	2	0
		4	7¼
Overhead charges and profit, say, 40 per cent. . . .		1	10¼
Basic cost per cubic foot		6	5½

	s.	d.
Cost per linear foot = 0·46 × 6*s.* 5½*d.*	= 2	11½
Trowelling, 1½ × 4 = 6 sq. ft. × 5 minutes = 30 minutes at 1*s.* 8*d.*	= 0	10
Nosing, 4 lin. ft. at 5 minutes per foot = 20 minutes at 1*s.* 8*d.*	= 0	6⅔
Reinforcement: 3 × 3 ft. 10 in. + 7 in. for hooks = 13 ft. 3 in. × 0·376 = 4·9 lb. at 3½*d.* = 1*s.* 5*d.* per step or $\frac{1s.\ 5d.}{4}$ per linear foot	0	4¼
Ex works price per linear foot	4	8½

On the basis of net volume the overall basic cost per cubic foot is

$$\frac{4s.\ 8\tfrac{1}{2}d.}{0{\cdot}46} = 10s.\ 3d.$$

On the basis of overall volume in accordance with the "Standard Method of Measurement" the basic cost per cubic foot is

$$\frac{4s.\ 8\tfrac{1}{2}d.}{0{\cdot}76} = 6s.\ 3d.$$

It must, of course, be obvious that the method of measurement should make no difference to the price of the step. Whether net volume or overall volume measurements are used the basic cost in either case should be such as to give the same cost per step.

Wall-hold or Stooling.—The additional net volume for a wall-hold 4½ in. wide is less than 0·1 cub. ft., and at 10*s.* 3*d.* per cubic foot can be taken as 1*s.* each; 9-in. wall-hold can be taken as 2*s.* each.

Mortices.—Where these are formed in casting they have to be set out carefully, and when the core is drawn on a face-up process the facing has to be made good. Allow 3*d.* each.

Concrete Lintels of Varying Section and Length.

EXAMPLE 40.—Compare the basic costs of the following lintels:

4½ in. × 6 in. × 4 ft.
4½ in. × 9 in. × 6 ft.
9 in. × 6 in. × 6 ft.
9 in. × 9 in. × 8 ft.
9 in. × 12 in. × 10 ft.

It is assumed that 20 casts can be obtained from each mould, and the moulds are to be made up from timber previously used for which a value of £20 a standard is asked. The concrete materials will cost 11*d.* per cubic foot and labour rates per hour will be: Carpenters, 2*s.*; makers, 1*s.* 7*d.*

The allowance for overhead charges and profit is to be taken at 25 per cent.

Analysis of Estimate.

With the exception of the moulds, the unit estimates can be obtained from tables. In order that the basic costs can be tabulated the mould charges will first be calculated, because a separate calculation will be necessary in each case and it will thus avoid detailed calculations in the table.

Lintel 4½ in. × 6 in. × 4 ft. = 0·75 cub. ft.

The contact area is (4½ in. × 4 ft.) + 2(6 in. × 4 ft.) + 2(4½ in. × 6 in.)
= 5·9, say, 6·0 sq. ft.

	£	s.	d.
Timber, 6 sq. ft. + 75 per cent. = 10·5 sq. ft. Using 2-in. timber at £20 a standard = 4·85*d.* per square foot, the cost is 10·5 × 4·85	= 0	4	3
Incidentals, add 10 per cent.	= 0	0	5
Labour for a mould of 6 sq. ft. is 75 min. per square foot, and at 2*s.* per hour	= 0	15	0
Indirect charges, add 33⅓ per cent.	= 0	5	0
	1	4	8

Output from mould, 20 × 0·75 = 15 cub. ft. Basic mould cost

$$=\frac{£1\ 4s.\ 8d.}{15},\ \text{say, 1}s.\ 8d.\ \text{per cubic foot.}$$

Lintel 4½ in. × *9 in.* × *6 ft.* = *1·7 cub. ft.*—

The contact area is (4½ in. × 6 ft.) + 2(9 in. × 6 ft.) + 2(4½ in. × 9 in.)

= 11·8, say, 12 sq. ft.

	£	s.	d.
Timber cost: 12 sq. ft. + 75 per cent. = 21 sq. ft. at 4·85*d*. =	0	8	6
Incidentals, add 10 per cent. =	0	0	10
Labour for a mould of 12 sq. ft. at 53 minutes per square foot, at 2*s*. per hour (say) =	1	1	0
Indirect charges, add 33⅓ per cent.	0	7	0
	1	17	4

Output from mould = 20 × 1·7 = 34 cub. ft. Basic mould cost

$$=\frac{£1\ 17s.\ 4d.}{34},\ \text{say, 1}s.\ 1d.\ \text{per cubic foot.}$$

It will be noted that these basic costs compare well with those in *Table* XII, and as the unit volume increases the basic costs reduce, so that it will be accurate enough to follow the table for the larger lintels.

Size of lintel.	4½ in. × 6 in. 4 ft.	4½ in. × 9 in. 6 ft.	9 in. × 6 in. 6 ft.	9 in. × 9 in. 8 ft.	9 in. × 12 in. 10 ft.
Volume (cub. ft.).	0·75	1·7	2·25	4·5	7·5
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Materials (concrete) . . .	0 11	0 11	0 11	0 11	0 11
Labour, casting and mixing at 1*s*. 7*d*. per hour . . .	1 2½ (46 m.p.c.)	0 9¼ (29 m.p.c.)	0 9¼ (29 m.p.c.)	0 7 (22 m.p.c.)	0 6¼ (20 m.p.c.)
Indirect charges, add 43 per cent.	0 6	0 3¾	0 3¾	0 2¾	0 2½
Moulds	1 8	1 1	1 0	0 9	0 7
	4 3½	3 1	3 0	2 5¾	2 3
Overheads and profit, 25 per cent.	1 1	0 9	0 9	0 7½	0 6¾
Basic cost per cubic foot ex works	5 4½	3 10	3 9	3 1¼	2 9¾

Reinforcement: Add ⅝-in. diameter and up at 3*d*. per lb. ⅜-in., but less than ⅝-in. diameter, 3½*d*. per lb.

Weights of Reinforcement in Lintels to carry Bonded Brickwork.

EXAMPLE 41.—What reinforcement is required for the first and last lintels of the previous example, if $f_c = 750$ lb. per square inch, $f_s = 18{,}000$ lb. per square inch and $M = 18$. The bearing at each end of the lintels is to be $4\frac{1}{2}$ in. The weight of brickwork is 120 lb. per cubic foot.

The weight of brickwork transmitting load to the lintel is the triangular portion above it of height two-thirds of the span between centres of supports.

Weight of brickwork over lintel.—$4\frac{1}{2}$ in. $\times$ 6 in. $\times$ 4 ft. $= W_1$

$$= \frac{3 \cdot 625^2}{2} \times \frac{2}{3} \times \frac{4 \cdot 5}{12} \times 120 = 197 \text{ lb.}$$

$$\text{Weight of concrete lintel} = W_2 = \frac{6 \times 4\frac{1}{2}}{144} \times 3 \cdot 625 \times 144 = 98 \text{ lb.}$$

$$\text{The combined moment is } \frac{W_1 l}{6} + \frac{W_2 l}{8}$$

$$= \frac{197 \times 3 \cdot 625}{6} + \frac{98 \times 3 \cdot 625}{8} = 119 + 44 \cdot 5$$

$$= 163 \cdot 5 \text{ lb.-ft.} = 1962 \text{ lb.-in.}$$

$$A_s = \frac{M}{f_s \times a \times d}, \text{ where } d = 6 - 1 = 5 \text{ in. and } a = 0 \cdot 857.$$

$$A_s = \frac{1962}{18{,}000 \times 0 \cdot 857 \times 5} = 0 \cdot 026 \text{ sq. in.}$$

Use one $\frac{1}{4}$-in. bar giving an area of 0·049 sq. in.

Weight of brickwork over lintel 9 in. $\times$ 12 in. $\times$ 10 ft. $= W_1$

$$= \frac{9 \cdot 625^2}{2} \times \frac{2}{3} \times \frac{9}{12} \times 120 = 2784 \text{ lb.}$$

$$\text{Weight of concrete lintel} = W_2 = 9 \cdot 625 \times \frac{9}{12} \times 144 = 1040 \text{ lb.}$$

$$\text{The combined moment is } \frac{W_1 l}{6} + \frac{W_2 l}{8}$$

$$= \frac{2784 \times 9 \cdot 625}{6} + \frac{1040 \times 9 \cdot 625}{8} = 4460 + 1250$$

$$= 5710 \text{ lb.-ft.} = 68{,}520 \text{ lb.-in.}$$

$$A_s = \frac{M}{f_s \times a \times d}, \text{ where } d = 12 - 1 = 11 \text{ in. and } a = 0{\cdot}857$$

$$A_s = \frac{68{,}520}{18{,}000 \times 0{\cdot}857 \times 11} = 0{\cdot}404 \text{ sq. in.}$$

This area is provided by one ½-in. bar	=	0·196 sq. in.
and one $\frac{9}{16}$-in. bar	=	0·248 „
		0·444 „

The bending moment due to dead weight only caused in handling is 1250 lb.-ft., or 15,000 lb.-in. To avoid fracture in case the lintel is turned upside down, additional steel should be placed in the top.

$$A_s = \frac{15{,}000}{18{,}000 \times 0{\cdot}857 \times 11} = 0{\cdot}089 \text{ sq. in.}$$

One ⅜-in. bar provides 0·110 sq. in.

Although, in the case of lintels for ordinary openings two- and three-brick courses deep, the depth is adequate to avoid excessive deflection or compressive failure, the estimator is warned against using the formula unless the depth is specified by the architect. In actual design the tensile, compressive, and shear stresses all have to be calculated and shown to be within the limits of safe stresses. If the depth is not specified an estimator unacquainted with the principles of reinforced concrete design should not take the responsibility of defining depths or quantities of reinforcement.

Duct Covers and Reinforced Slabs.

EXAMPLE 42.—Estimate the cost of a slab 2½ in. thick by 1 ft. 9 in. wide in lengths of 2 ft. 6 in. The slabs are to be made face up, with hard-trowelled finish, and are to be reinforced with expanded metal costing approximately 1*s*. 10*d*. per square yard. The concrete materials will cost 1*s*. 1*d*. per cubic foot; labour costs 1*s*. 6*d*. per hour; overheads and profit are to be taken at 33⅓ per cent. The delivery requirements will allow 30 castings to be obtained from each mould.

$$\text{Volume of slab} = \frac{2{\cdot}5}{12} \times 1{\cdot}75 \times 2{\cdot}5 = 0{\cdot}91 \text{ cub. ft.}$$

Analysis of Estimate.

		Basic cost per cubic foot. s. d.
Materials		1 1
Labour:		
	m.p.c.	
Casting	= 41	
Mixing	= 2	
Indirect charges + 43 per cent.	= 18	
At 1s. 6d. per hour	= 61	1 6
Moulds (from *Table* XII)		1 1
Reinforcement $\frac{2{\cdot}5 \times 1{\cdot}75}{9} \times$ 1s. 10d. = 10·7d. per slab		1 0
Hard trowelling at 4 minutes per square foot = $17\frac{1}{2}$ minutes per slab, or 19 minutes per cubic foot at 1s. 6d. per hour		0 6
		5 2
Overhead charges and profit $33\frac{1}{3}$ per cent.		1 9
Basic cost ex works		6 11

The cost per slab is 0·91 × 6s. 11d., say, 6s. 3d.

Paving Slabs or Flags.

Certain manufacturers specialise in paving flags made in hydraulic presses. To make paving economically by hand in separate moulds it is essential to assume a production of 100 or so casts from each mould. Also special arrangements can be made to reduce labour costs, and the reduced figures of 15 m.p.c. and 15 minutes per casting can be used as mentioned in Chapter IX.

EXAMPLE 43.—Estimate the cost per square yard of 2-in. paving in standard sizes of 2 ft. by 2 ft., 2 ft. by 2 ft. 6 in., and 2 ft. by 3 ft. The concrete materials can be taken at 11*d.* per cubic foot, labour at 1*s.* 6*d.* per hour, and overheads and profit at 25 per cent.

Analysis of Estimate.

For the purposes of the analysis, take the average size of slab as 2 ft. × 2 ft. 6 in. × 2 in. thick.

$$\text{Volume} = 2{\cdot}0 \times 2{\cdot}5 \times \frac{2 \text{ in.}}{12} = 0{\cdot}84 \text{ cub. ft.}$$

		Basic cost per cubic foot. s.	d.
Materials		0	11
Labour:	m.p.c.		
Casting, 15 m.p.c. + 15 min. per unit = 15 m.p.c. + 18 m.p.c.	= 33		
Mixing	= 2		
Indirect charges, add 43 per cent.	= 14		
	49 at 1*s.* 6*d.*	1	2¾
Moulds, say 100 casts from each mould		0	4½
		2	6¼
Add 25 per cent, overheads and profit, say . . .		0	7½
		3	1¾

$$\text{Price per square yard} = 9 \times \frac{2 \text{ in.}}{12} \times 3s.\ 1\tfrac{3}{4}d. = 4s.\ 8\tfrac{1}{2}d.$$

Kerb.

Concrete kerbs are made to standard sizes and shapes in accordance with B.S.S. No. 340. Standardisation enables large stocks to be carried which are always in demand, and therefore it is possible to estimate an output of, say, 500 castings from a steel mould. The moulds are supplied from stock by most mould manufacturers.

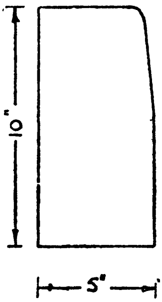


Fig. 44.

EXAMPLE 44.—Estimate the cost of a 5-in. by 10-in. by 3-ft. half-battered kerb in accordance with B.S.S. No. 340 as illustrated in *Fig.* 44 (*Fig.* 4 in B.S.S. No. 340). The concrete is to be composed of 4 parts

of ½-in. down to ¼-in. granite chips, 2 parts of sharp washed sand, and 90 lb. of Portland cement. Material prices are: Granite chips 18*s.* 6*d.* per ton, sand 8*s.* 6*d.* per cubic yard, Portland cement 60*s.* per ton. Labour 1*s.* 6*d.* per hour; steel moulds 50*s.* each; overheads and profit to be taken at 25 per cent.

$$\text{Volume} = \frac{5 \text{ in.} \times 10 \text{ in.}}{144} \times 3 \text{ ft.} = 1{\cdot}04 \text{ cub. ft.}$$

Analysis of Estimate.

	s.	d.
Materials, 1 : 2 : 4 from *Table* II:		
510 lb. Portland cement at 60*s.* per ton	= 13	8
0·42 cub. yd. sand at 8*s.* 6*d.* per cub. yd.	= 3	7
0·93 cub. yd. × 27 × 110 = 2762 lb. granite chips at 18*s.* 6*d.* per ton	= 22	10
	40	1
Add 5 per cent. for waste	= 2	0
	42	1

		Basic cost per cubic foot. s.	d.
Materials: $\frac{42s.\ 1d.}{27}$ =		1	6½
Labour:			
Making, say, 15 m.p.c.			
[Because time of mould stripping with standard steel moulds is very much reduced, and in view of the mass production methods which can be used.]	m.p.c.		
Indirect charges need only be 25 per cent.	= 19		
Mixing, at 1*s.* 6*d.* per hour	= 2		
	21	0	6¼
Moulds: $\frac{50s.}{500 \times 1{\cdot}04}$, say		0	1¼
		2	2
Add 25 per cent. for overheads and profit		0	6½
		2	8½

Cost per yard length = 2*s.* 8½*d.* × 1·04, say, 2*s.* 10*d.*

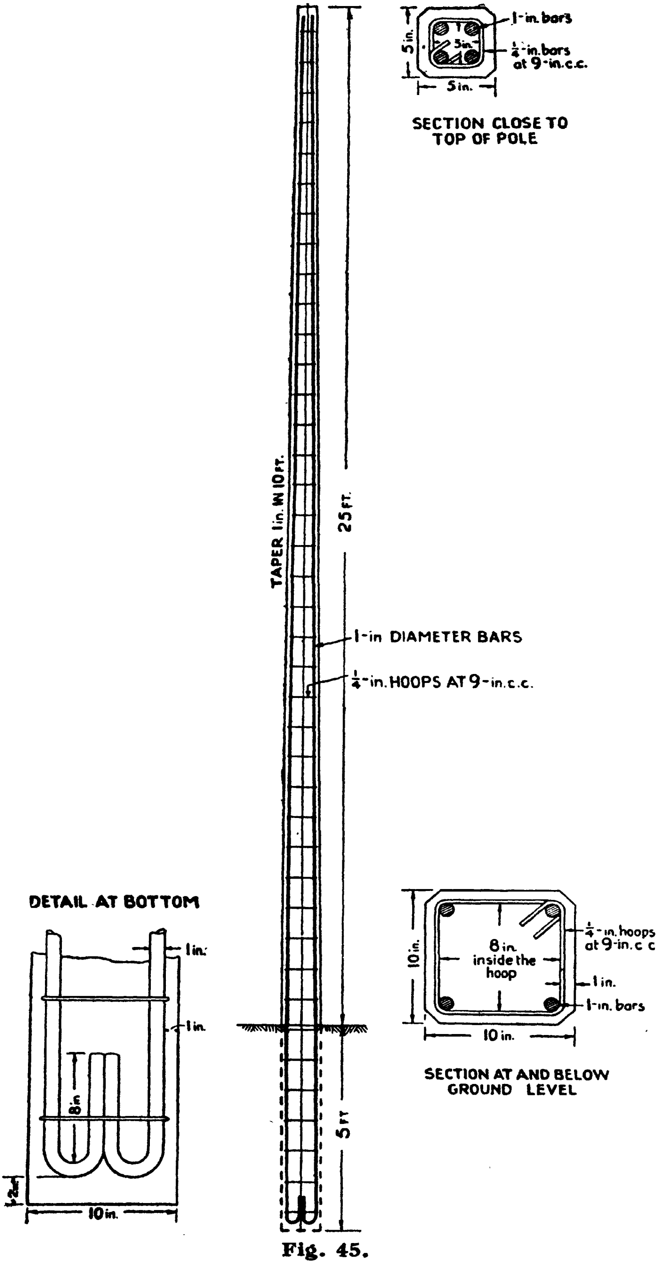

1-in. bars
5 in.
5 in.
$\frac{1}{4}$-in. bars at 9-in. c.c.
5 in.
SECTION CLOSE TO TOP OF POLE
TAPER 1 in. IN 10 FT.
25 FT.
1-in DIAMETER BARS
$\frac{1}{4}$-in. HOOPS AT 9-in. c.c.
DETAIL AT BOTTOM
1 in.
1 in.
8 in.
10 in.
5 FT
$\frac{1}{4}$-in. hoops at 9-in. c c
8 in. inside the hoop
10 in.
1 in.
1-in. bars
10 in.
SECTION AT AND BELOW GROUND LEVEL

Fig. 45.

Poles and Lamp Standards.

EXAMPLE 45.—Estimate the cost of the reinforced concrete transmission line pole illustrated in *Fig.* 45. The concrete is to be composed of 4 volumes of ballast ¾-in. down, 2 volumes of sharp washed sand, and 1 volume of Portland cement. The price is to be estimated on obtaining 15 casts from each mould. All hoops to be tied to main reinforcement with 16-gauge wire.

Material prices: ¾-in. down ballast, 10*s*. 6*d*. per cubic yard; sand, 8*s*. 6*d*. per cub. yd.; Portland cement, 60*s*. per ton; timber, £50 per standard; reinforcement, £17 2*s*. 0*d*. per ton basis.

Wages: Carpenters, 2*s*. per hour; concretors, 1*s*. 7*d*. per hour; steel benders and fixers, 1*s*. 10*d*. per hour.

$$\text{Volume of pole} = (0{\cdot}174 + 0{\cdot}695 + \sqrt{0{\cdot}121})\frac{25}{3} + (0{\cdot}695 \times 5)$$
$$= (1{\cdot}217 \times 8{\cdot}33) + 3{\cdot}475$$
$$= 10{\cdot}16 + 3{\cdot}48 = 13{\cdot}64 \text{ cub. ft.}$$

(*See next page for Analysis of Estimate.*)

Analysis of Estimate.

		Basic cost per cubic foot. *s.* *d.*
Materials:	*s.* *d.*	
Cement, 505 lb. at 60*s.* per ton	= 13 6	
Sand, 0·41 cub. yd. at 8*s.* 6*d.*	= 3 6	
$\frac{3}{4}$-in. ballast, 0·81 cub. yd. at 10*s.* 6*d.*	= 8 6	
	25 6	
Add 5 per cent. for waste	1 3	
Cost per cubic yard	= 26 9	
Cost per cubic foot	$= \frac{26\ 9}{27}$, say,	1 0
Labour:	m.p.c.	
Casting (from Table VII)	18	
Placing reinforcement	2	
Mixing	2	
Indirect charges 43 per cent. × 18	8	
	30	
Contingencies: A great deal of care is required in levelling the floor to receive the moulds to avoid distortion. The moulds are also cumbersome and require more handling. It is therefore wise to increase the casting charges by, say, 50 per cent.	15	
	45	
At 1*s.* 7*d.* per hour, 45 m.p.c., say		1 2

Moulds: The contact area of one face is

$$\left(\frac{10 \text{ in.}}{12} \times 5 \text{ ft. } 0 \text{ in.}\right) + \left(\frac{10+5}{12 \times 2} \times 25 \text{ ft.}\right) = 19{\cdot}8 \text{ sq. ft.}$$

The contact area of three faces = 19·8 × 3 = 59·4 sq. ft.
" " " ends = 0·9

60·3 sq. ft.

Timber, using 3-in. for sides and bottom $= 60{\cdot}3 \times \frac{3 \text{ in.}}{12}$ say, 15 cub. ft. + 75 per cent., say 26 cub. ft.

	£ *s.* *d.*
Timber cost per mould $= \frac{£50}{165} \times 26$	= 7 17 7
Incidentals, add 10 per cent.	0 15 9
	8 13 4

			Basic cost per cubic foot. s. d.
Labour: 60·3 sq. ft. at 30 minutes per square foot + 270 minutes constant, say,	35 hours		
Indirect charges: + 33 per cent., say,	12 ,,		
At 2*s*. per hour	47 ,, =	4 14 0	
Total cost of mould	=	13 7 4	
If 15 castings are to be produced from each mould the basic cost is $\frac{£13\ 7s.\ 4d.}{15 \times 13{\cdot}64}$ = 1*s*. 3·7*d*., say			1 4
Trowelling top face at 3 minutes per square foot = 19·8 × 3, say, 60 minutes at 1*s*. 7*d*.			
Basic cost = $\frac{19}{13{\cdot}64}$, say			0 1½
Add 40 per cent. for overheads and profit			1 5½
Cost per cubic foot			5 1
Cost per pole, ex works, exclusive of reinforcement = 13·64 × 5*s*. 1*d*., say,			69 0
Reinforcement Material:			
Four 1-in. bars 30 ft. 6 in. long = 122 ft. at 2·670 lb. per foot = 325·7 lb. and at £17 2*s*. 0*d*. basis . . .			49 8
Seven ¼-in. hoops 3 ft. 4 in. long = 23 ft. 4 in.			
33 average 2 ft. 6 in. long = 82 ft. 6 in.			
105 ft. 10 in.			
At 0·167 lb. per foot = 17¾ lb. at £19 2*s*. 0*d*. . .			3 0
Add for waste and rolling margin, 10 per cent. . .			5 3
Labour:			
Handling and cutting 326 lb. of 1-in. bar at 2·7 cwt. per hour = $326 \times \frac{1s.\ 10d.}{2{\cdot}7 \times 112}$ =			2 0
Handling and cutting 18 lb. of ¼-in. bar at 1·5 cwt. per hour = $18 \times \frac{1s.\ 10d.}{1{\cdot}5 \times 112}$ =			0 2½
Bending 326 lb. of 1-in. bar at 1·4 cwt. per hour = $326 \times \frac{1s.\ 10d.}{1{\cdot}4 \times 112}$ =			3 10
Bending 18 lb. of ¼-in. bar at 0·7 cwt. per hour = $18 \times \frac{1s.\ 10d.}{0{\cdot}7 \times 112}$ =			0 5
Fabricating 160 ties at 65 per hour = $\frac{160}{65}$ × 1*s*. 10*d*. =			4 6
			68 10½
Add 40 per cent. for overheads and profit . . .			27 6½
			96 5

Cost of reinforcement frame per pole = £4 16*s.* 5*d.*

		£	*s.*	*d.*
Cost per pole	=	3	9	0
Reinforcement	=	4	16	5
Total price per pole ex works	=	8	5	5

It is very convenient when analysing an estimate to arrive at a basic price per cubic foot inclusive of reinforcement, because when the detailed calculations have been made a few times an experienced estimator can tell almost upon inspection of a drawing what the basic price should be. Note in this example the high cost of reinforcement. The reinforcement reduced to a cubic-foot basis is $\frac{\pounds 4\ 16s.\ 5d.}{13{\cdot}64} = 7s.\ 1d.$ per cubic foot approximately. This is, of course, exceedingly high in relation to the other material, and similar high charges for reinforcement are to be expected with heavily-loaded reinforced concrete beams. It shows the necessity for accurate determination of the correct lengths and weights of steel.

CHAPTER XX

EXAMPLES OF CO-ORDINATING ESTIMATES FOR CAST STONE MASONRY

In the following examples of analysing estimates of cast stone the material costs in every case have been taken from *Tables* V and VI. The tables were compiled from the following prices of facing materials:

White Portland cement . . . . . £10 5*s*. 0*d*. per ton
Facing aggregates at an average price of . £1 10*s*. 4*d*. per ton
Mix: 1 volume of cement to 3½ volumes of aggregate.
Average price of facing material, 4*s*. 3*d*. per cubic foot.
Average price of concrete backing, 1*s*. 1*d*. per cubic foot.

Facing materials vary in all parts of the country, and are usually selected to resemble a local or well-known natural stone. The prices vary considerably, and as the cost is greatly in excess of ordinary concrete aggregates the manufacturer should adjust these tables to suit the prices he pays, as the material charges, particularly in small sections, represent a large item in the basic cost.

Plain Cast Stone Ashlar and Blocking Courses.

Ashlar is usually measured in cubic feet with a specified bed of 4½ in. or 9 in., or an average of 6¾ in., although many surveyors specify this as 7 in. The only reason for increasing the bed by ¼ in. is to facilitate calculations, but it means an increase in volume of 3·7 per cent., and as plain ashlar represents one of the biggest items in a stone-faced building, there is no reason why the volume should not be calculated more exactly. The price is influenced by volume, but as sizes are seldom specified an average volume of an ashlar block can be taken as

$$3 \text{ ft. long} \times 1 \text{ ft. high} \times 6\tfrac{3}{4} \text{ in. bed} = 1{\cdot}69, \text{ say, } 1{\cdot}7 \text{ cub. ft.}$$

Example 46.—On the assumption that 15 casts are produced from a mould, and taking mould-maker's wages at 2*s*. per hour, maker's wages at 1*s*. 8*d*. per hour, and overhead charges and profit at 40 per cent., the basic cost is made up as follows.

Analysis of Estimate.

6¾-in. bed, semi-dry process.

		s.	d.
Materials, from *Table* VI (one face)		1	6½
	m.p.c.		
Labour: Casting	67		
Mixing	2		
Indirect charges, 43 per cent. of 67 m.p.c.	29		
At 1s. 8*d.* per hour	98 =	2	9
Moulds, 15 casts per mould		1	7
		5	10½
Overhead charges and profit, 40 per cent.		2	4½
Basic price per cubic foot ex works		8	3

EXAMPLE 47.—What is the price per cubic foot of 4½-in. ashlar based on the labour and material prices of the previous example?

Volume = 3 ft. × 1 ft. × 4½ in. = 1·13 cub. ft.

Analysis of Estimate.

4½-in. bed, semi-dry process.

		s.	d.
Materials		1	6½
	m.p.c.		
Labour: Casting	73		
Mixing	2		
Indirect charges	32		
At 1s. 8*d.* per hour	107 =	3	0
Moulds		1	10
		6	4½
Overhead charges and profit 40 per cent.		2	6½
Basic price per cubic foot ex works		8	11

EXAMPLE 48.—Estimate the cost per linear foot of a plain ashlar lintel 8 ft. long × 12 in. high × 9-in. bed. Fair face and soffit, and reinforced with two ½-in. bars. Labour and material prices as before, but only 10 casts from a mould.

Analysis of Estimate.

Volume of lintel = 8 × 1 × 0·75 = 6·0 cub. ft.

	m.p.c.	s.	d.
Materials (2 faces)		1	5½
Labour: Casting	52		
Mixing	2		
Indirect charges 43 per cent.	22		
At 1*s*. 8*d*. per hour	76 =	2	1½
Moulds, 10 casts per mould		1	3
		4	10
Overheads and profit, 40 per cent.		1	11
Basic price per cubic foot ex works		6	9
Price per linear foot = 0·75 × 6*s*. 9*d*.	=	5	1
Reinforcement, two ½-in. bars at 0·668 lb. per foot = 1·34 lb. at 3½*d*. per lb. = 4¾*d*., say,		0	5
Price per linear foot		5	6

Plain Cast Stone Ashlar with Chisel Dressed Finish.

Example 49.—Estimate the cost per cubic foot of 9-in. bed cast-stone ashlar in 12-in. courses, with face chisel dressed 8 to 12 bats to the inch.

Analysis of Estimate.

Volume, taken as 9 in. × 12 in. × 3 ft. 0 in. = 2·25 cub. ft.

	m.p.c.	s.	d.
Materials, from *Table* VI (one face)		1	5½
Labour: Casting	64		
Mixing	2		
Indirect charges, 43 per cent. of 64	= 28		
At 1*s*. 8*d*. per hour	94 =	2	7½
Moulds, say, 15 casts per mould		1	4
Chisel dressing at 30 minutes per square foot $= 30 \times \frac{12}{9} = 40$ minutes per cubic foot at 2*s*. per hour (mason's rate)		1	4
		6	9
Overhead charges and profit, 40 per cent.		2	8
Price per cubic foot ex works		9	5

Note that the cost per cubic foot for chisel dressing $4\frac{1}{2}$-in. ashlar would be $30 \times \frac{12}{4\frac{1}{2}} = 80$ minutes at 2*s.* per hour, which would be 2*s.* 8*d.* per cubic foot.

Cast Stone Copings.

EXAMPLE 50.—Make a comparison of the basic cost of the following copings: 11-in. by 3-in. section, 12-in. by 4-in. section, and 13-in. by

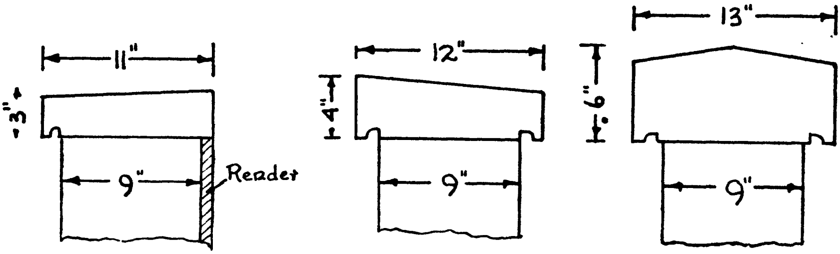


Fig. 46.

6-in. section as illustrated in *Fig.* 46. They are to be cast semi-dry, and it is estimated that 40 castings will be required from each mould. Concrete maker's rate 1*s.* 8*d.* per hour.

Analysis of Estimate.

	11 in. by 3 in.	12 in. by 4 in.	13 in. by 6 in.
Volume of 3 ft. length (cub. ft.)	0·69	1·0	1·63
	s. d.	*s. d.*	*s. d.*
Materials, from *Table* VI (three faces)	2 6½	2 4	2 1½
Labour: Casting, including mixing	2 7	2 2½	1 11
Indirect charges, add 43 per cent.	1 1	0 11½	0 10
Moulds	1 0	0 9	0 7
	7 2½	6 3	5 5½
Overhead charges and profit, 40 per cent.	2 10½	2 6	2 2½
Basic price per cubic foot ex works	10 1	8 9	7 8

Fair ends to coping, 6*d.* each.
Mitres: Take as price per linear foot to the nearest whole shilling.
Mortices for dowels, and cramps, 3*d.* each.

Cast Stone Sills.

EXAMPLE 51.—Make a comparison of the basic cost per cubic foot of the following sills: 6-in. by 3-in. section, 9-in. by 3½-in. and 11-in. by 6-in. as illustrated in *Fig.* 47. The sills are to be sunk, weathered,

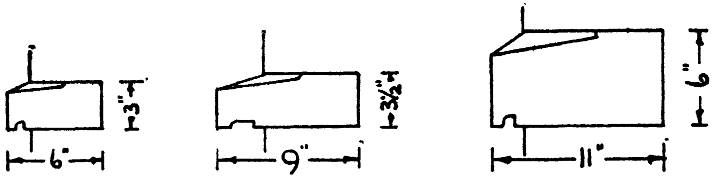


Fig. 47.

throated, and stooled, and are to be cast semi-wet with rubbed finish. It is estimated that 10 castings will be obtained from a mould. The concrete maker's rate is 1*s.* 8*d.* per hour.

Analysis of Estimate.

	6 in. by 3 in.	9 in. by 3½ in.	11 in. by 6 in.
Volume of 3-ft. lengths (cub. ft.)	0·375	0·66	1·38
	s. d.	*s. d.*	*s. d.*
Materials, from *Table* VI (two faces)	2 5½	2 2	1 9½
Labour: Casting, including mixing	3 3	2 4½	1 9½
Indirect charges, add 43 per cent.	1 5	1 0	0 9
Moulds (these would be classified moulded; the price should therefore be increased by 50 per cent.)	8 6	5 10½	3 7½
	15 7½	11 5	7 11½
Overhead charges and profit, 40 per cent.	6 3	4 7	3 2
Basic cost per cubic foot ex works	21 10½	16 0	11 1½

The cost of wall-holds and stoolings is included in the "moulded" mould charge, and no extra need be charged. Sills are usually measured in linear feet and the wall-holds numbered, from which the average length of the sills can be obtained to assist in more accurate determination of the estimate.

High charges for moulds always occur with small sections, and it is

for this reason that the volume is small when only a few castings are required from a special mould. It is therefore apparent that some standardisation of small sections would enable large output from a mould to be obtained, resulting in great reductions in the basic mould costs.

Cast Stone Stringcourses.

These sections being moulded on the face save materials, but on the other hand finishing costs will be a little more expensive and the moulds may be fairly complicated, so that it is as well to estimate on overall sizes.

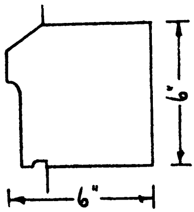


Fig. 48.

EXAMPLE 52.—Estimate the cost per linear foot of a moulded stringcourse, illustrated in *Fig.* 48, 6 in. by 6 in. extreme section, which is to be cast semi-wet. It is estimated that 15 castings can be obtained from each mould. The maker's rate is 1*s.* 6*d.* per hour.

Analysis of Estimate.

$$\text{Volume of 3-ft. length} = \frac{6 \text{ in.} \times 6 \text{ in.}}{144} \times 3 \text{ ft.} = 0{\cdot}75 \text{ cub. ft.}$$

	s.	*d.*
Materials, from *Table* VI (two faces)	2	1
Labour: Casting, including mixing = 79 m.p.c.	2	c
Indirect charges, add 43 per cent.	0	10½
Moulds (add 50 per cent. for moulded)	3	6
	8	5½
Overheads and profit, 40 per cent.	3	4½
Basic cost per cubic foot ex works	11	10

$$\text{Cost per linear foot} = \frac{6 \text{ in.} \times 6 \text{ in.}}{144} \times 11s.\ 10d. = 2s.\ 11\tfrac{1}{2}d.$$

Cast Stone Cornices.

Although cornices are moulded and sometimes very elaborately ornamented, the basic cost per cubic foot is not necessarily high because the volume is high in comparison with many other dressings, resulting in low material and casting labour charges. The increased mould charges are amply covered by adding to *Table* XII 50 per cent. for " moulded," and by making no deduction for the actual saving of material costs in the cut-away portion, effected by measuring on overall dimensions. If only one or two castings were required from a mould it is probable that the mould charges would not be adequately covered by adding 50 per cent. to *Table* XII and measuring overall, so that some additional allowance should be made in the estimate to compensate for the loss of material costs resulting from lack of repetition.

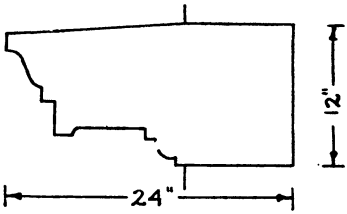


Fig. 49.

EXAMPLE 53.—Estimate the cost per cubic foot of a moulded cornice 2 ft. wide × 1 ft. deep in 3-ft. lengths as illustrated in *Fig.* 49. It is estimated that 20 castings can be obtained from each mould, and the semi-wet process is to be used. The maker's rate is 1*s.* 7*d.* per hour.

Analysis of Estimate.

Overall volume of 3-ft. length is 2 ft. × 1 ft. × 3 ft. = 6 cub. ft.

	Basic cost per cubic foot. *s.*	*d.*
Materials, from *Table* VI (3 faces)	1	9
Labour: Casting (semi-wet) including mixing = 45 + 2 = 47 m.p.c. at 1*s.* 7*d.*	1	3
Indirect charges, add 43 per cent.	0	6½
Moulds, add 50 per cent. for moulded	1	0
	4	6½
Overheads and profit, 40 per cent.	1	10
Cost per cubic foot ex works	6	4½

The cost of mitres and return ends should be estimated as the nearest price to a whole shilling of the price per linear foot. The cost per linear foot is 2 ft. × 1 ft. × 6*s.* 4½*d.* = 12*s.* 9*d.*, and the cost of each mitred return end should be 13*s.*

Cast Stone Arches.

Repetition can seldom be expected for arches to door entrances, although window arches are likely to be repeated in certain types of buildings. If the item is billed in cubic feet, the figure itself should be a clue whether there will be repetition.

EXAMPLE 54.—Estimate the average cost per cubic foot of the arch illustrated in *Fig.* 34 if only one arch is to be made. The maker's rate is 1*s.* 7*d.* per hour, and the semi-wet process is to be used.

Analysis of Estimate.

The springer and voussoirs to both sides of the arch are "handed," and therefore only one cast can be obtained from each mould. For convenience the estimate can be based on the average cube per unit. The total volume is:

	cub. ft.
2/1 ft. 11 in. × 1 ft. 9 in. × 9 in. =	2·88
2/2 ft. 4 in. × 1 ft. 5 in. × 9 in. =	4·95
2/2 ft. 1 in. × 1 ft. 8 in. × 9 in. =	5·40
1/1 ft. 5 in. × 1 ft. 3 in. × 9 in. =	1·32
Total . .	14·55

The average volume per unit is $\dfrac{14{\cdot}55 \text{ cub. ft.}}{7 \text{ units}} = 2{\cdot}08$ cub. ft.

	Basic cost per cubic foot. *s.*	*d.*
Materials, from *Table* VI (two faces)	1	8½
Labour: Casting, including mixing = 57 m.p.c. at 1*s.* 7*d.* per hour	1	6
Indirect charges, 43 per cent.	0	8
Moulds, add 50 per cent. for circular and one cast only per mould	30	4½
	34	3
Overheads and profit, 40 per cent.	13	9
Cost per cubic foot ex works	48	0

CHAPTER XXI

CO-ORDINATED ESTIMATES IN TABULATED FORM

THE examples in the two previous chapters illustrate how most basic prices can be compiled from the tables previously given. It will be apparent that the basic cost varies with the volume and the degree of repetition from the moulds to a far greater extent than any other cause. Although complicated mould assembly must of necessity affect the basic cost, it does not do so to anything like the extent that may be imagined. The correct assessment of volume rate and mould repetition has a much more important effect in the determination of an accurate price. For example, take a casting of 2 cub. ft. volume, which has a complicated mould assembly. The rates quoted in the tables with the addition of indirect charges already include for stripping an ordinary mould, and this being so only the additional time in stripping and assembling requires consideration. Much additional work can be done by two men in 15 minutes, which at 1*s*. 7*d*. per hour costs 9½*d*. (or 4¾ cub. ft.). Now compare this with the difference of 1*s*. per cubic foot between estimating 10 castings from a mould when in reality 15 can be obtained. It is wise to cover the cost of any contingency arising from complicated work, but if it is carelessly assumed that only 10 castings can be obtained from a mould when 15 can be got, instead of the price being

$$4s.\ 9d. + 4\tfrac{3}{4}d. = 5s.\ 1\tfrac{3}{4}d. \text{ per cubic foot}$$

it would be 5*s*. 9*d*. + 4¾*d*. = 6*s*. 1¾*d*. per cubic foot, an error of practically 20 per cent. on the high side.

In order that the important influence of repetition on cost can be immediately appreciated the detailed tables given in the previous chapters have been co-ordinated so that any basic price can be obtained upon inspection, given the conditions of volume per unit and repetition. The author believes that he is the inventor of such methods of quick and accurate estimating, and the detailed methods described throughout the book will enable manufacturers and estimators to prepare their own cost charts according to their labour and material costs. The tables in this chapter will prove to be of inestimable value. It must be borne in mind, however, that the mould charges are calculated from assumed contact area of typical 3-ft. sections, and if the shapes and sizes are unusual the mould charges should be checked. For the pricing of an

TABLE XVII.

Plain Wet Cast Concrete made in Wood Moulds including Placing Reinforcement																					
Unit Volume cub. ft.	Sectional Area of 3'0" length	Basic Cost per Cubic Ft ex. Wks. for Various Outputs																	Add for		Material and Labour Costs
		1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	50	Reinforcement		Moulded	
	Sq. In.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.		per lb.		
0·3	14·4	93/6	50/-	35/6	28/4	23/10	21/-	19/-	17/5	16/2	15/2	12/4	10/10	10/-	9/5	9/-	8/9	8/4	1/4" diam	4d.	See separate table for price differential	Mould makers 2s. hr.
0·4	19·2	80/7	43/0	30/7	24/3	20/7	18/-	16/3	14/11	13/11	13/1	10/7	9/4	8/7	8/1	7/9	7/5	7/1	3/8" "	3½d.		Casters 1s 7d. hr.
0·5	24·0	72/2	38/6	27/3	21/8	18/2	16/0	14/6	13/3	12/3	11/7	9/4	8/3	7/6	7/0	6/8	6/6	6/2	1/2" "	3¼d.		Labourers 1s. 6d. hr.
0·6	28·8	62/9	33/8	23/11	19/0	16/1	14/1	12/9	11/9	10/11	10/3	8/4	7/4	6/9	6/5	6/1	5/11	5/8	5/8" "	3d.		
0·7	33·6	56/3	30/3	21/7	17/3	14/8	12/11	11/8	10/8	10/0	9/5	7/8	6/9	6/4	6/0	5/9	5/7	5/4	and up			Timber £50 Std.
0·8	38·4	50/7	27/3	19/5	15/7	13/3	11/8	10/7	9/8	9/1	8/7	7/0	6/3	5/9	5/5	5/3	5/1	4/11				Cement £2/16/6 ton
0·9	43·2	46/3	24/11	17/11	14/4	12/3	10/11	9/11	9/1	8/5	8/0	6/8	5/11	5/7	5/3	5/0	4/11	4/8				Ballast 12s. yd.
1·0	48·0	43/9	23/9	17/0	13/8	11/8	10/4	9/5	8/8	8/1	7/8	6/4	5/8	5/4	5/0	4/11	4/8	4/5				Sand 13s. yd.
1·1	52·8	40/7	22/11	15/11	12/11	11/0	9/9	8/11	8/3	7/8	7/3	6/0	5/5	5/1	4/9	4/8	4/7	4/4				
1·2	57·6	38/9	21/1	15/3	12/3	10/7	9/4	8/7	7/11	7/4	7/0	5/9	5/3	4/11	4/8	4/5	4/4	4/3				Concrete 1s. 1d. cu. ft.
1·3	62·5	36/9	20/1	14/7	11/8	10/0	8/11	8/1	7/7	7/1	6/8	5/7	5/0	4/8	4/5	4/4	4/3	4/0				
1·4	67·3	35/1	19/4	14/0	11/4	9/8	8/8	7/11	7/4	6/11	6/7	5/5	5/0	4/8	4/5	4/4	4/3	4/0				Overheads and
1·5	72·0	33/11	18/7	13/5	10/11	9/4	8/4	7/8	7/1	6/8	6/4	5/4	4/9	4/5	4/3	4/1	4/0	3/11				Profit 33⅓ per cent.
2·0	96·0	30/0	16/7	12/0	9/9	8/5	7/7	6/11	6/5	6/0	5/9	4/9	4/4	4/1	3/11	3/9	3/8	3/7				
3·0	144·0	23/9	13/4	9/9	8/1	7/0	6/4	5/9	5/5	5/1	4/11	4/3	3/11	3/8	3/7	3/5	3/4	3/3				No Finishing included
4·0	192·0	22/5	12/8	9/4	7/9	6/9	6/1	5/8	5/3	5/0	4/9	4/1	3/10	3/7	3/5	3/4	3/4	3/3				
5·0	240·0	19/9	11/3	8/4	7/0	6/1	5/9	5/1	4/11	4/7	4/5	3/11	3/7	3/4	3/3	3/3	3/1	3/0				
6·0	288·0	18/11	10/9	8/1	6/9	6/0	5/5	5/0	4/9	4/7	4/4	3/10	3/7	3/4	3/3	3/3	3/1	3/0				
7·0	336·0	18/1	10/4	7/9	6/6	5/8	5/3	4/9	4/7	4/4	4/1	3/8	3/4	3/3	3/1	3/0	3/0	2/11				
8·0	384·0	17/1	9/11	7/5	6/3	5/5	5/0	4/8	4/5	4/3	4/0	3/7	3/4	3/3	3/1	3/0	3/0	2/11				

TABLE XVIII.

UNIT VOLUME cub. ft.	SECTIONAL AREA OF 3 ft. length	BASIC COST PER CUBIC FT. EX WKS. FOR VARIOUS OUTPUTS 1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	50	ADD FOR TWO FACES	THREE FACES	SEMI DRY	MOULDING	MATERIAL AND LABOUR COSTS
	Sq. In.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.				SEE SEPARATE TABLE FOR PRICE DIFFERENTIAL	
0·3	14·4	102/5	56/9	41/6	33/11	29/4	26/3	24/2	22/6	21/3	20/2	17/2	15/8	14/9	14/1	13/8	13/5	12/11	4d.	1s.1d.	3d.		Mould makers 2s. hr.
0·4	19·2	87/10	48/5	35/4	28/9	24/10	22/2	20/4	18/11	17/10	17/0	14/4	13/1	12/3	11/9	11/5	11/1	10/9	4d.	1s.1d.	3d.		Casters 1s.7d.hr.
0·5	24·0	78/9	43/5	31/7	25/10	22/1	19/10	18/2	16/11	15/10	15/2	12/10	11/7	10/10	10/5	10/1	9/10	9/5	4d.	1s.1d.	3d.		Labourers 1s.6d.hr.
0·6	28·8	68/9	38/2	27/11	22/9	19/9	17/7	16/3	15/2	14/3	13/6	11/7	10/6	9/11	9/7	9/3	9/0	8/9	4d.	1s.0d.	3d.		
0·7	33·6	61/7	34/4	25/3	20/8	18/0	16/2	14/10	13/9	13/1	12/6	10/7	9/8	9/3	8/10	8/8	8/5	8/2	4d.	11d.	3d.		Timber £50 Std.
0·8	38·4	54/9	31/2	23/0	18/11	16/5	14/10	13/8	12/9	12/2	11/7	9/11	9/1	8/9	8/4	8/1	7/11	7/8	4d.	11d.	3d.		Cement
0·9	43·2	51/0	28/7	21/3	17/6	15/3	13/11	12/10	12/0	11/4	10/10	9/6	8/8	8/4	7/11	7/8	7/7	7/4	4d.	11d.	3d.		White £10/5/0 ton
1·0	48·0	48/4	27/4	20/2	16/8	14/7	13/2	12/3	11/5	10/10	10/5	9/0	8/3	7/11	7/7	7/5	7/3	7/0	4d.	11d.	3d.		Grey 2/16/6 ton
1·1	52·8	44/9	26/3	18/11	15/9	13/9	12/6	11/7	10/10	10/3	9/10	8/6	7/11	7/7	7/3	7/1	7/0	6/9	4d.	10d.	3d.		Facing Sand 1/10/6 "
1·2	57·6	42/10	24/4	18/1	14/11	13/2	11/11	11/1	10/5	9/10	9/5	8/2	7/7	7/3	7/0	6/9	6/8	6/6	4d.	10d.	3d.		Ballast 12s. cu.yd.
1·3	62·5	40/9	23/3	17/5	14/4	12/7	11/5	10/7	10/1	9/7	9/1	7/11	7/4	7/0	6/9	6/8	6/7	6/4	4d.	10d.	3d.		Sand 13s. cu.yd.
1·4	67·3	38/10	22/3	16/8	13/11	12/2	11/1	10/3	9/8	9/3	8/10	7/9	7/3	6/11	6/8	6/6	6/5	6/2	4d.	10d.	3d.		
1·5	72·0	37/6	21/6	16/1	13/5	11/9	10/9	10/0	9/5	8/11	8/8	7/7	7/0	6/8	6/5	6/4	6/2	6/1	4d.	10d.	3d.		Facing 4s.3d. cu. ft.
2·0	96·0	33/4	19/3	14/6	12/2	10/9	9/10	9/1	8/8	8/2	7/11	6/11	6/5	6/2	5/11	5/10	5/9	5/7	4d.	9d.	3d.		Backing 1s.1d. " "
3·0	144·0	26/9	15/9	12/0	10/3	9/1	8/5	7/10	7/6	7/2	6/11	6/2	5/10	5/7	5/6	5/5	5/3	5/2	4d.	9d.	3d.		
4·0	192·0	25/1	14/10	11/4	9/8	8/8	7/11	7/6	7/0	6/9	6/7	5/10	5/6	5/3	5/2	5/0	5/0	4/11	4d.	9d.	3d.		Overheads and
5·0	240·0	22/3	13/4	10/3	8/10	7/11	7/4	6/11	6/8	6/4	6/2	5/7	5/3	5/0	4/11	4/11	4/9	4/8	4d.	9d.	3d.		Profit 40 per cent.
6·0	288·0	21/3	12/9	9/11	8/6	7/9	7/2	6/8	6/5	6/2	6/0	5/5	5/2	4/11	4/10	4/10	4/8	4/7	4d.	9d.	3d.		
7·0	336·0	20/5	12/3	9/7	8/2	7/4	6/11	6/5	6/2	5/11	5/9	5/3	4/11	4/10	4/8	4/7	4/7	4/5	4d.	9d.	3d.		
8·0	384·0	19/4	11/9	9/3	7/11	7/2	6/8	6/4	6/1	5/10	5/7	5/2	4/11	4/10	4/8	4/7	4/7	4/5	4d.	9d.	3d.		

Table title: PLAIN SEMI-WET CAST STONE MADE IN WOOD MOULDS — FAIR ONE FACE

average bill of quantities for general building work, tables compiled as in this chapter enable very rapid and accurate estimates to be quoted.

The figures quoted in all the tables in this book may be safely used by most manufacturers, but the first opportunity should be taken of checking working times for casting and mould making, because so many different processes are used which influence the time rate of production. When time-rate figures have been verified for castings of various volumes, tables can be compiled in accordance with the methods described so that, using the actual rates of pay and material charges, a final chart of selling prices can be produced.

In *Tables* XVII, XVIII, and XIX the allowance for overhead charges and profit have been taken as: Cast stone, 40 per cent.; concrete

TABLE XIX.

PRICE DIFFERENTIAL TO ADD FOR "MOULDED" WORK																		
UNIT VOLUME cub. ft.	SECTIONAL AREA OF 3'0" lengths	BASIC COST PER CUBIC FT. EX. WKS. FOR VARIOUS OUTPUT																
		1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	50
	Sq. ins.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
0·3	14·4	43/6	21/9	14/6	10/10	8/8	7/3	6/3	5/5	4/10	4/4	2/11	2/2	1/9	1/6	1/3	1/1	0.11
0·4	19·2	37/6	18/9	12/6	9/4	7/6	6/3	5/4	4/8	4/2	3/9	2/6	1/11	1/6	1/4	1/2	1/0	0.10
0·5	24·0	33/8	16/10	11/3	8/5	6/8	5/7	4/10	4/3	3/9	3/5	2/3	1/8	1/4	1/2	1/0	0.10	0.8
0·6	28·8	29/2	14/7	9/8	7/3	5/10	4/10	4/2	3/8	3/3	2/11	1/11	1/6	1/2	1/0	0.10	0.9	0.8
0·7	33·6	26/6	13/0	8/8	6/6	5/3	4/4	3/9	3/3	2/11	2/7	1/9	1/4	1/1	0.11	0.10	0.8	0.7
0·8	38·4	23/4	11/8	7/9	5/10	4/8	3/11	3/4	2/11	2/7	2/4	1/7	1/2	1/0	0.10	0.8	0.8	0.6
0·9	43·2	21/3	10/7	7/1	5/3	4/3	3/7	3/1	2/8	2/4	2/1	1/6	1/1	0.11	0.9	0.8	0.7	0.6
1·0	48·0	20/1	10/1	6/8	5/0	4/0	3/4	2/11	2/6	2/3	2/0	1/4	1/0	0.10	0.8	0.8	0.6	0.5
1·1	52·8	18/6	9/8	6/2	4/8	3/9	3/1	2/8	2/4	2/1	1/10	1/3	1/0	0.10	0.8	0.7	0.6	0.5
1·2	57·6	17/8	8/10	5/11	4/5	3/7	3/0	2/7	2/3	2/0	1/9	1/2	0.11	0.9	0.8	0.6	0.6	0.5
1·3	62·5	16/9	8/5	5/8	4/2	3/4	2/9	2/5	2/3	1/11	1/8	1/2	0.10	0.8	0.7	0.6	0.6	0.4
1·4	67·3	15/11	8/0	5/4	4/0	3/2	2/8	2/3	2/0	1/10	1/8	1/1	0.10	0.8	0.7	0.6	0.6	0.4
1·5	72·0	15/4	7/8	5/1	3/10	3/1	2/7	2/3	2/0	1/9	1/7	1/1	0.9	0.8	0.6	0.6	0.5	0.4
2·0	96·0	13/6	6/9	4/6	3/5	2/9	2/4	2/0	1/9	1/6	1/5	0.11	0.8	0.7	0.6	0.5	0.4	0.4
3·0	144·0	10/6	5/3	3/6	2/8	2/1	1/10	1/6	1/4	1/2	1/1	0.9	0.7	0.7	0.5	0.4	0.4	0.3
4·0	192·0	9/10	5/0	3/4	2/6	2/0	1/8	1/6	1/3	1/2	1/0	0.8	0.6	0.5	0.4	0.4	0.4	0.3
5·0	240·0	8/7	4/4	2/10	2/2	1/9	1/6	1/3	1/2	1/0	0.11	0.8	0.6	0.4	0.4	0.4	0.3	0.2
6·0	288·0	8/1	4/1	2/9	2/1	1/8	1/5	1/2	1/1	1/0	0.10	0.7	0.6	0.4	0.4	0.4	0.3	0.2
7·0	336·0	7/9	3/11	2/8	2/0	1/7	1/4	1/2	1/0	0.11	0.10	0.7	0.5	0.4	0.4	0.3	0.3	0.2
8·0	384·0	7/3	3/8	2/6	1/10	1/6	1/3	1/1	1/0	0.10	0.9	0.6	0.5	0.4	0.4	0.3	0.3	0.2
OVERHEADS AND PROFIT INCLUDED 33⅓ PER CENT.																		

products, 33⅓ per cent., but here again adjustment should be made for the figures actually in use.

Upon reference to *Tables* XVII and XVIII it will be noticed how great is the difference in the basic rates for increasing repetition, and the importance of an accurate estimation of delivery time.

If it is assumed that 40 castings are to be obtained from a mould by a manufacturing process which only allows stripping every 24 hours, and one week is allowed for the preparation of details and moulds, and one week for the maturing of the final casting, the delivery date for completion is

$$\frac{40}{5\tfrac{1}{2}\text{-day week}} = 7\tfrac{1}{4} + 2 = 9\tfrac{1}{4}, \text{ say, } 10 \text{ weeks.}$$

There are not many contracts where a period of this length can be allowed for delivery; usually a customer expects to get delivery in four weeks, when it is only possible to get an average of about 10 castings from a mould. The tables emphasise this column, as it will most probably be used more than any other.

Table XIX has been compiled of the price differential to add to the basic cost of plain castings when estimating for moulded work.

Finishing Costs and Sundry Items.—To facilitate rapid estimating when using *Tables* XII and XVIII, the times for finishing and sundries from Chapter X are repeated here.

Scrubbed surface: 10 minutes per square foot.

Trowelling: Rough, 3 sq. ft. per minute; hard, 5 minutes per square foot for small areas and 3 minutes per square foot for large areas.

Chisel dressing (8 to 12 bats to the inch): 30 minutes per square foot.

Dragged finish: 5 minutes per square foot.

Polishing: 60 to 90 minutes per square foot.

Mortices for dowels, bolts, cramps, etc.: 3*d.* each.

Cutting holes: Up to 3 in. diameter, 6*d.* per inch of depth; 3 in. to 6 in. diameter, 9*d.* per inch of depth. Forming holes up to 6 in. diameter at time of casting: 6*d.* each.

Stoolings or wall-holds: 1*s.* each.

Fair ends up to 1 sq. ft., material only: 6*d.* each.

Mitres and angles: Price to nearest whole shilling the cost per linear foot of straight run of material on which mitre is formed.

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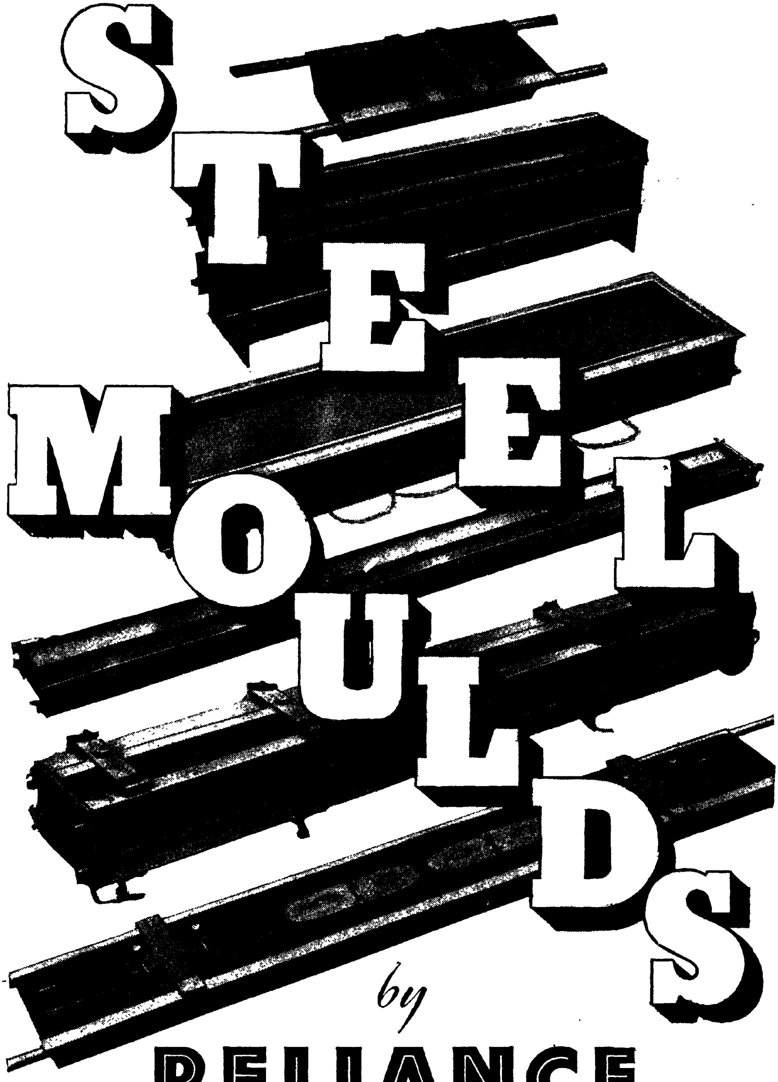
[*Continued on p.* 134.

Concluded from p. 132.]


STEEL
MOULDS
by

ATLAS LIFTING TRUCK

reduces handling costs in precast concrete work

FREEDOM FROM JOLTING ELIMINATES BREAKAGES

We illustrate the most popular lifting truck in the concrete industry. Its gentle lift and smooth running ensure the moving of concrete units from the machine to the stacking yard without cracking the newly-made concrete. It is controlled by the steering handle only, and is never-failing in making the handling of concrete units easy and speedy.

The large number in daily use throughout the industry is proof that the ATLAS LIFTING TRUCK is economical and highly efficient. ● Send for full details.

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THE "CUMFLOW" CONCRETE MIXER SAVES CEMENT

This famous Mixer was recently tested at the Building Research Station, and the report on these tests proves conclusively that with a Mixer such as the "Cumflow", which really *does* mix, there is a point at which additional cement does not increase the strength of the concrete but may actually weaken it. The chart below gives these interesting figures:

AVERAGE STRENGTH in lbs. per sq. inch at 7 DAYS:

	MIXED IN A "CUMFLOW" MIXER		
Mixing Time in Minutes	1 : 2 : 4 Mix. Water-Cement Ratio, 0·48	1 : 1½ : 3 Mix. Water-Cement Ratio, 0·42	The addition of 25 per cent. more cement increased strength by only
1	5,450	5,830	7%
2	5,460	5,950	9%
4	5,900	6,100	2%

There are over 400 "Cumflow" Mixers in use all over the British Isles. Write for further details and a complete copy of the Building Research report.

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Correct Mixing Technique

PEGSON COUNTER CURRENT MIXER

Here is the perfect mixing system for any aggregate. A mixing pan rotating on trunion rollers in the opposite direction to a mixing star mounted eccentrically to the pan. In combination their coating activities are unique and the greatest possible strength from a minimum cement content is assured. Every batch is mixed with the same precision, in a fraction of the time necessitated by other systems. Every batch is uniform in quality. Renewable manganese cast steel blades are fitted to the spring-loaded mixing arms of the star. All main shafts are on ball bearings which are totally enclosed against dust and grease. All parts of the rotating system are easily cleaned and controlled. The freely hung kneading roller does not crush the aggregate but breaks down any nodules of a soft or hard nature. The discharge valve is one-third the diameter of the mixing pan, and the mixed batch is rapidly and completely ejected.

Fullest particulars of

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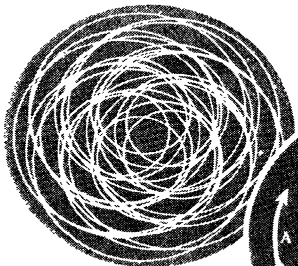

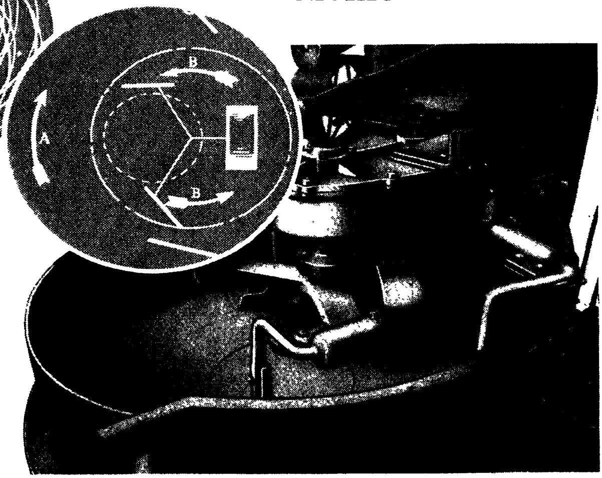

(*Top circle*). The traverse of the mixing elements during one revolution of the pan.

(*Lower circle*). Illustrates the arrangement of the mixing star and the scrapers. The arrow (*a*) shows the direction of the revolution of the pan and (*b*) the direction of the revolution of the star.

The photograph on the right shows the mixing star and the totally enclosed gears.

★ HORSEHAY STEEL MOULDS ★

ALL-ROUND ECONOMIES IN MOULDS, LABOUR & TIME

The steel mould is the only answer to repetition work in the production of precast concrete units. It effects a considerable saving in mould costs and, because its face is more smooth than a timber mould, it eliminates finishing costs.

All steel moulds supplied by us are suitable for hand tamping and vibrating, designed for easy and rapid fixing and stripping, strongly constructed for long life, accurate in every detail, and finished to produce a smooth clean concrete surface.

Illustrated on the opposite page are some of our steel moulds, of which large numbers are in daily use throughout the industry.

HUT UNITS

The first illustration shows a battery of moulds for casting units for the M.O.W. Standard Concrete Hut. Single units for this class of work are also available.

SLEEPERS

The second illustration shows a steel mould for producing concrete sleepers to the B.C.F. standard. Moulds for other types of sleepers can also be supplied.

LAMP COLUMNS

The third illustration shows a special mould for spinning lamp columns. Owing to the intricate design of the column, the mould was made in cast iron with a mild steel outer case to take all stresses due to spinning.

PIPES

The bottom illustration shows some of the pipe moulds supplied by us. Our range includes moulds for 9-in. to 72-in. diameter pipes.

SPECIAL MOULDS

can be supplied to meet all requirements, including cast iron moulds for ornamental work.

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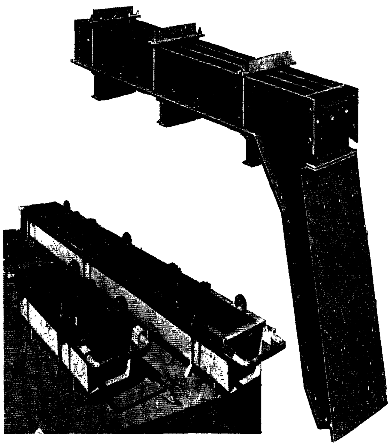
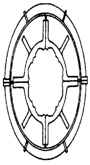
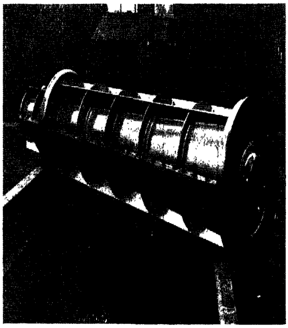
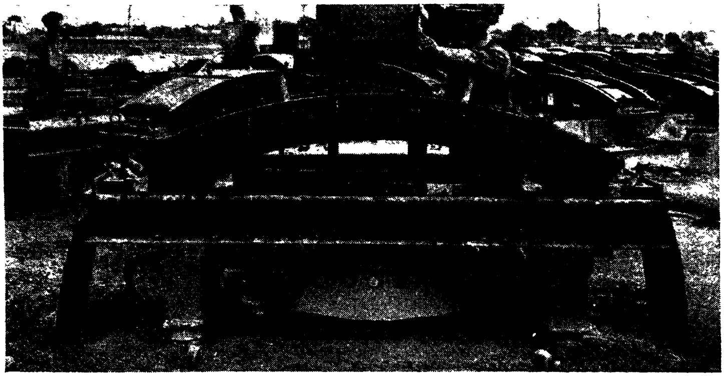




Section showing C.I. Mould encased in M.S. outer shell





"SHERWEN" VIBRATORS

The Sherwen electro-magnetically-operated high-frequency table with its 3000 impacts per minute is recognised by Engineers and Contractors as a positive means for successfully compacting concretes with low water-cement ratios which were formerly considered harsh and unworkable.

Concrete segments for the Underground Railway tunnels and deep shelters are made on the Sherwen Tables illustrated above. The special impact vibrator developed for this class of work requires no lubrication, has no rotating or wearing parts other than the anvil, and can be operated direct from any A.C. supply.

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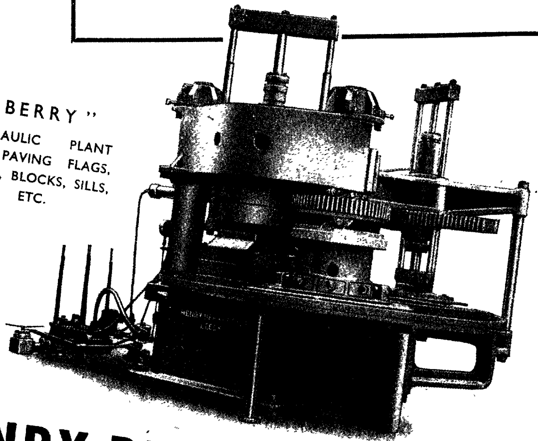
can be answered satisfactorily only by consulting specialists in pressed-concrete production plant who are in a position to give details of output, capital outlay, maintenance costs, and labour required. With our long experience of pressed-concrete products we have available complete particulars of the rapid production of concrete flags, kerbs, etc., which will be gladly sent to those who are considering the installation of plant for large daily outputs.

"BERRY" HYDRAULIC PLANT FOR PAVING FLAGS, KERBS, BLOCKS, SILLS, ETC.



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